A STUDY OF THE MAGNESIUM CONTENT OF SOILS AND PLANTS

by

PHILIP CROOKS

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VOLUME I - TEXT AND TABLES

VOLUME I

TABLE OF CONTENTS

VOLUME I - TEXT AND TABLES.

Key to Experiments, Treatments and Sites.

Abbreviations.

n.c. = no cut.

T(n) = the total of n cuts (in grass experiments)

VOLUME II - FIGURES.

$0 \overset{**}{>} 1$ means that the yield or uptake with the applied nutrient (N, K or Mg) is less than that without that nutrient, at the 1 per cent level of probability.

$0 < 1$ means that the yield or uptake with the applied nutrient (N, K or Mg) is greater than that without that nutrient, but the difference is not statistically significant.

$p \leqslant 0.05$, $p \leqslant 0.01$ and $p \leqslant 0.001$ are represented by *, ** or $\overset{*}{*}$ and *** or $\overset{**}{*}$ respectively.

n.c. = no cut.

I. INTRODUCTION

Magnesium is a major plant nutrient but because the majority of our soils have been able to supply sufficient for healthy crops it has been treated, until recently, as if it were a trace element.

While soil-magnesium levels were formerly maintained by the application of fertilisers containing magnesium as an impurity, the introduction and continuous use of fertilisers containing few impurities, higher optimum fertiliser rates for new and improved crop varieties and the resulting increased need for 'lime' have caused the 'available' magnesium supply to decrease by accelerating leaching losses and encouraging greater uptakes in crops. In addition, the 'available' supply can be rendered less available to crops by the antagonism of other cations. Thus magnesium-deficiency symptoms now appear frequently in crops in S.E. Scotland. Although there have been no startling yield responses from the application of magnesium fertilisers, in this area, serious economic crop losses would inevitably result if the depletion of the magnesium reserves were allowed to continue.

On some farms in this area, magnesium deficiency of ruminants is already a serious economic problem but this can be prevented by increasing the quantity of magnesium in the diet. Because of the immediate possibility of hypomagnesaemic tetany or of crop failure in the future, it is thought necessary to apply regularly a suitable magnesium fertiliser.

The aim of this investigation was to study, in field experiments, the effects of fertilisers, containing N, K and Mg, on the amount of magnesium removed by grass, clover, mixed herbage, barley and potatoes and on the exchangeable soil magnesium.

II. REVIEW OF LITERATURE

The earth's outer crust (the lithosphere), down to a depth of 10 miles, consists of igneous and metamorphic rocks with a thin interrupted layer of sedimentary rocks on top. The lithosphere contains igneous rocks (95 per cent), shale (4 per cent), sandstone (0.75 per cent) and limestone (0.25 per cent) (Clarke and Washington, 1924). Using the average concentration of Mg in each group of rocks in conjunction with the proportions of each class given above, the lithosphere to a depth of 10 miles, contains about 2 per cent Mg, which is much more than the total Mg concentration of most soils.

Purves (1962) found that the range of total Mg concentration in soil samples from 100 temporary, grass fields, selected at random from S. E. Scotland, was from 0.16 to 3.40 per cent. Since the frequency distribution of these results is skew the median value of 0.68 per cent Mg is a better parameter than the mean for summarising these results. If these 100 soil samples are representative of the soils of this area the loss of Mg by leaching, following the weathering of the minerals, has been considerable.

In a review of the literature on the Mg relationships in soils and plants, Salmon (1963) postulates that the main mineral reserves of 'available' Mg in British soils are the micas, chlorites and most of the clay minerals. Therefore, while Mg deficiency in plants on soils of a light texture is likely to have been the result of a real lack of Mg, this deficiency on a heavier soil would perhaps have been caused by ion antagonism. It is my intention to deal with these two broad textural classes first and then, later to deal with ion antagonism.

Texture.

The most severe cases of magnesium deficiency have occurred on light-textured soils. The occurrence in N. America of 'sand drown', magnesium

deficiency of the tobacco plant (called 'sand drown' because it is most severe on deep, sandy soils and is accentuated by heavy rainfall), was first reported by Garner et al.(1922). In a review of the literature, McMurtrey (1947) reported that 'sand drown' occurred more frequently on the light-sandy and sandy-loam soils with 0.024 to 0.24 per cent total Mg and was more severe in seasons of very high rainfall. Because the sandy soils in the Coastal Plain of New Jersey, where 'sand drown' was common, contain some kaolinitic clay which does not have Mg as a constituent (Hester et al., 1947) they contain less Mg than soils with similar texture but with montmorillonite as the clay mineral (Ross and Hendricks, 1941). The heavier soils (loam to silty-clay loam) in the northern part of New Jersey, with considerable quantities of magnesite, dolomite, and serpentine retain more exchangeable Mg (Prince et al.,1947) than the Coastal Plain soils. Foy and Barber (1958) commented that the conditions which are generally associated with this deficiency are low pH (less than 5.5) and sandy, highly-leached soils.

Until remedial action was taken, magnesium deficiency of cereals ('Hooghalen disease') frequently occurred on the Dutch sandy and sand-peat soils and, although the symptoms were often temporary, serious outbreaks sometimes caused considerable crop losses. Its occurrence was associated with acidity, and complete recovery was attained only when lime and a magnesium salt were applied (Jessen, 1931; Gehring et al., 1931). Ferrari and Sluijsmans (1955) determined a limiting level of exchangeable Mg for 'Hooghalen disease' of about 2.2 mg per 100 g soil and a critical pH (in N KCl) of 4.8.

In field experiments in Florida (Blue and Eno, 1956), Mg deficiency symptoms in forage plants were consistently obtained on two out of the

seven soil types examined; both were fine sands with a low pH (5.1 to 5.9) and exchangeable Mg concentration of from 0.4 to 3.7 mg per 100 g soil.

Greenham and White (1959) found Mg deficiency in apple-tree leaves associated with a sandy-loam soil having an exchangeable Mg concentration of 4 mg per 100 g.

Out of 30 potato experiments, Holmes (1962a) obtained significant yield increases from the application of $MgSO_4$ at only 4 sites. The soils at these sites were either sands or sandy loams with a high pH at 3 sites induced by liming, and with an exchangeable Mg concentration of from 1 to 6 mg per 100 g soil.

Harrod and Caldwell (1967) commented that, although symptoms of deficiency were found in crops on a range of soil textures from loamy sands to clay, Mg deficiency caused by low soil Mg is generally confined in East Anglia to the loamy sands and sandy loams. Although the majority of these soils are now neutral or alkaline through liming, most were originally acid.

The results of the analysis of many soil samples in Germany (Michael and Schilling, 1957; Selke, 1960), Denmark (Henriksen, 1964), Holland (Broek and Marel, 1959) and N. Scotland (Reith, 1963) indicate that, while light-textured soils are generally low in 'available' magnesium, heavier soils are well supplied.

By means of a survey of the Mg concentrations in soil samples of known cropping and fertiliser treatment, from the principal soil types in Missouri (mainly silt loams), Albrecht et al. (1943) deduced that the percentage Mg saturation was decreasing more rapidly in soils whose 'productivity' was being increased with lime and fertilisers.

Ion Antagonism.

Since the pH of British soils is controlled by the extent of the mutual

replacement of Ca and H ions, it is more convenient to consider the antagonisms of Ca and of H on Mg together, under the heading of pH. The effects of K and of NH_4 on Mg will be considered under separate headings.

(i) pH.

The antagonism between H and Mg, at pH values below optimum for healthy plant growth, cannot easily be dissociated from the harmful effects of low pH values on plant roots, although the individual effects are quite different. Van Itallie (1936), for example, by applying a Mg salt, only removed the Mg-deficiency symptoms from oats suffering from 'Hooghalen disease' and attempts to restore the normal colour to the leaves by increasing only soil pH, were nearly always unsuccessful (van Itallie, 1937), although yield was invariably increased. Complete recovery was attained only when lime and a magnesium salt were applied (see p.3).

MacIntire (1933) postulated that (a) Mg deficiency in an acid soil was the result of depletion of the 'available' Mg supply, but (b) deficiency symptoms could be induced by the addition of calcitic liming-materials which exerted a "protective effect" on the Mg reserves and thus retarded hydrolysis of the Mg complexes. Since it is now known that (a) applies to light textured soils but not to heavier soils which contain Mg in the clay minerals and that (b) is only part of the explanation for the antagonistic effect of Ca, these effects will be considered separately.

(a). In a soil where 'Hooghalen disease' had occurred, Smit and Mulder (1942) found no 'available' Mg (by A.niger) at pH 4.0 where the total-Mg concentration was 20.4 mg per 100 g soil. At pH 5.4, however, the same soil contained 4 mg 'available' Mg per 100 g soil. There must therefore have been a greater leaching loss of Mg at the lower pH value.

In sandy soils with pH values of from 4.5 to 7.5, corresponding to base

saturation percentages of 14 and 72 respectively, Mehlich (1942) reported that the amount of Mg lost by leaching from the surface of these soils increased with decreasing base saturation, i.e. with decreasing pH. Once lost from the surface the Mg was not retained by an acid subsoil, irrespective of its texture and cation exchange capacity. However, the capacity of the subsoil for retaining Mg was increased by increasing its percentage base saturation. After further work, Mehlich and Reed (1945) reported that losses of Mg by leaching from a sandy loam were less at high than at low levels of Ca saturation.

A reduction in the 'available' Mg supply is therefore the cause of the H - Mg antagonism in light soils.

(b) In naturally-occurring acid soils, with a texture heavier than sandy loam, Barshad (1960a) found that the proportions of exchangeable cations were affected by the chemical composition of the clay minerals. By means of an exchange reaction, adsorbed H displaces structural Mg and Al which become exchangeable cations. As a result, Mg saturation can increase with a decrease in pH. An increase in Ca saturation, at the expense of exchangeable H, would therefore retard this process. Barshad (1960b) found that Mg constituted a substantial percentage of the total exchangeable cations in acidified clay samples from various sources. Also, that the exchangeable Ca:Mg ratios in Californian soils, formed under similar, soil-forming condition, except parent material, are in the following order - granitic > basaltic > serpentine soils.

The net effect of H on Mg availability will depend on texture and pH. In addition to controlling the rate of leaching and/or the rate of hydrolysis of clay minerals, pH also affects plant-root systems and thus Mg availability. This latter effect can occur even at pH values where the Ca-Mg antagonism is operating.

McCart and Kamprath (1965) found that a greater yield of cotton and uptake of Mg occurred when the pH of light soils was raised from 5.5 to 6.5 with calcitic limestone and that an equal uptake of Mg resulted from the application of 0.3 me. Mg per 100 g soil at pH 6.0 and 0.15 me. at 6.5. Unfortunately the Mg concentrations in the cotton at these 2 pH levels were not reported, but Adams and Henderson (1962), with a range of soil textures, reported that increasing the pH from 5.5 to 6.5 with $CaCO_3$ had no effect on the Mg concentration of Sudan grass and, on some soils, reduced that of ladino clover. However, because of improved growth, the uptake of Mg was greater at the higher pH where the 'available' Mg supply was adequate, but the reverse occurred where Mg was limiting growth.

An antagonism between Ca and Mg occurs when applied Ca displaces exchangeable Mg, and the magnitude of the antagonism is governed by the extent of the displacement. Moschler et al. (1960) reported that the application of 16 tons per acre of either calcitic or dolomitic limestone to a silt loam increased the pH from 4.9 to 6.8. While dolomitic limestone increased the exchangeable soil Mg from 0.20 to 2.24 me. Mg per 100 g soil and the Mg concentration in alfalfa from 0.19 to 0.35 per cent, calcitic limestone had no effect on exchangeable Mg and decreased alfalfa Mg from 0.19 to 0.16 per cent. Mehlich and Reed (1945) found that, although leaching losses of Mg were less at higher base saturation percentages, losses were increased by the application of $CaSO_4$. Thus while the Mg concentration in cotton increased with increasing percentage base saturation the addition of $CaSO_4$ invariably lowered this concentration. Plant (1953) and Alston (1966a) also found that the Mg concentration in plant material was decreased after the addition of $CaSO_4$.

In a critical review, Lipman (1916) concluded that there was little or no evidence to support the necessity for a specific Ca:Mg ratio for plant growth as had been postulated by Loew and May (1901). Halstead et al. (1958), in soils of varying texture, produced exchangeable Ca:Mg ratios ranging from 0.6:1.0 to 5.0:1.0 by using $MgCO_3$, and from 4.1:1.0 to 13.5:1 by using $CaCO_3$, without affecting the yield of alfalfa. When compared with the control, $MgCO_3$ decreased exchangeable Ca and increased Mg, and $CaCO_3$ at an equivalent rate, decreased exchangeable Mg and increased Ca. Because a higher degree of base saturation had been established with the $CaCO_3$, compared with $MgCO_3$, the increase in exchangeable Ca with $CaCO_3$ was greater than the increase in exchangeable Mg with $MgCO_3$ (expressed in me.). With the control as the reference treatment, $MgCO_3$ increased the Mg and decreased the Ca concentration in alfalfa, whereas $CaCO_3$ increased the Ca and decreased the Mg concentration. However, the $MgCO_3$ reduced the Ca more than $CaCO_3$ reduced Mg (expressed in me.). Hunter (1949), using alfalfa, and Jacoby (1961) with citrus seedlings, also reported decreases in Mg concentration resulting from an increase in the exchangeable Ca:Mg ratio. Calcium-Mg antagonism is therefore likely to occur where applied Ca displaces exchangeable Mg. This can occur as a result of the addition of $CaCO_3$ to soils, the pH values of which are near neutrality (Alten and Werner, 1960; Pfaff and Buchner, 1958), but where the pH was low, these workers and Alston (1966a) found that the addition of $CaCO_3$ increased the Mg concentration in plant material.

Since an increase in Mg concentration in plant material can result from the addition of $CaCO_3$ to very acid soils, the adverse effect of low pH values on Mg uptake must be greater than that of pH values which are optimum for agricultural crops.

(ii) NH_4 - Mg antagonism.

Arnon (1937 and 1939); Wadleigh and Shive (1939); Evans and Weeks (1947); McEvoy (1954) used nutrient solutions with a constant level of N to compare the effects of NH_4- and NO_3-N on the composition of plants.

Arnon, with nutrient solutions in which nitrification did not take place, found that the Mg concentration in barley plants was lower with NH_4- than with NO_3-N at pH values ranging from 4.0 to 6.7. Wadleigh and Shive, applying nutrient solutions by a continuous flow method and using sand as a root medium, reported that the Mg concentration in corn plants was highest at pH 3 and lowest at pH 8, and that NH_4-N, compared with NO_3-N, lowered the Mg concentration at similar pH values. Using sand and nutrient solutions maintained at pH 5.8, Evans and Weeks found that NO_3-N produced nearly six times as much DM and increased the Mg concentration in the DM of tobacco by 100 per cent compared with NH_4-N. Treatments containing half NH_4-N and half NO_3-N produced intermediate results. These workers postulated that the smaller absorption of Mg from the NH_4-N solutions was caused by the large excess of active NH_4 ions in solution, which also accounted for the relatively greater uptake of the following anions - phosphate, chloride and sulphate. (Cunningham and Nielsen 1965, reported that many more cations ($(NH_4\text{-N}) + Na + K + Ca + Mg$ in me. per 100 g DM) than anions ($(NO_3\text{-N})$ + organic N + P + Cl + S in me. per 100 g DM) were taken up by grass when given NH_4-N and nitrification was inhibited, but that the reverse occurred with NO_3-N. When nitrification was not prevented, Cunningham and Karim (1965) found that the sum of the cations (Na + K + Ca + Mg in me. per 100 g DM) in ryegrass increased with increasing NO_3-N, but with NH_4-N the sum of cations tended to a maximum value and decreased with more NH_4-N).

McEvoy, in sand-culture work with tobacco comparing the effects of NH_4-

and NO_3-N, used 3 levels of NH_4-N (N_0, N_1 and N_2, which correspond to levels 2, 1 and 0 respectively of NO_3-N) in factorial combination with 3 levels of SO_4(S_0, S_1 and S_2). Sodium and Cl which were used as the 'balancing ions' had not produced Mg-deficiency symptoms in earlier work. The Mg concentration in the tobacco leaf was depressed by both NH_4 and SO_4, and was generally inversely related to the quantities of NH_4 and SO_4 in the nutrient solution. Symptoms of Mg deficiency occurred in plants grown in N_2 in combination with S_1 and S_2. The Mg-deficiency symptoms were most severe and the Mg concentration was lowest with N_2 S_2.

In pot experiments using a sandy soil of pH 5.2 (water) with $(NH_4)_2SO_4$, NH_4NO_3 and either $NaNO_3$ or $Ca(NO_3)_2$ as sources of N, Mulder (1956) reported that, where Mg was not applied, Mg-deficiency symptoms appeared in oat and wheat plants at the second or third leaf, and were more pronounced with $(NH_4)_2SO_4$ than with NH_4NO_3. The severity of these symptoms increased with N rate, but no symptoms appeared with either $Ca(NO_3)_2$ or $NaNO_3$. However, when Mg was applied, no Mg-deficiency symptoms appeared with $Ca(NO_3)_2$, $NaNO_3$ or NH_4NO_3 but severe deficiency symptoms appeared at high rates of $(NH_4)_2SO_4$. Similar results were obtained with wheat in field experiments, where $(NH_4)_2SO_4$, 'Nitro-Chalk' and $Ca(NO_3)_2$ were the sources of N.

In field experiments, Mulder found (a) a detrimental effect from NH_4-N and (b) a beneficial effect from NO_3-N on the yield of potatoes, which he postulates were due to (a) a reduced uptake of Mg due to the NH_4 antagonism and (b) an increased uptake of Mg with NO_3-N resulting from an improved root system.

Mulder concluded that $(NH_4)_2SO_4$ has two harmful effects on plant- and

soil-Mg: these are (a) the antagonism of NH_4 on Mg uptake during growth and (b) a greater loss of 'available' Mg, during a wet autumn and winter following application, from a soil which has been made more acid by the use of $(NH_4)_2SO_4$. (At the conclusion of one experiment the pH values in aqueous suspension, after using $Ca(NO_3)_2$, NH_4NO_3 and $(NH_4)_2SO_4$, were 5.0, 4.3 and 4.1 respectively).

Where high levels of N were applied over 2 years (up to 536 lb N per acre), Wolton (1960) found that although the Mg concentration in herbage was increased by increasing the N-rate with either NH_4NO_3 or $(NH_4)_2SO_4$, the increases, at corresponding levels of N, were much less with $(NH_4)_2SO_4$ than with NH_4NO_3. While NH_4NO_3 had little effect on pH and Mg status, $(NH_4)_2SO_4$ consistently decreased pH and exchangeable Mg. In one experiment on a sandy loam, the pH and exchangeable Mg values after 2 years, with 180 and 536 lb N per acre as $(NH_4)_2SO_4$, were 7.2 and 5.6 (soil pH); 4.5 and 2.6 mg Mg per 100 g soil. However, this author did not find such clear-cut differences between various sources of N in short-term experiments, and her data suggest that the differences between sources of N may be of practical significance only where heavy dressings are applied continually.

Like Mulder, Wolton concludes that lower Mg concentration in plants from $(NH_4)_2SO_4$ applications are due, in the first instance, to the antagonistic effect of the NH_4 ion and over a period to a reduction in the soil pH and Mg status.

The following workers have obtained results which appear to contradict the above. However, these differences can be explained by consideration of the effects of pH on nitrification.

In a pot experiment, Alston (1966b) found that $Ca(NO_3)_2$ increased the

Mg concentration in oat plants to a greater extent than $(NH_4)_2SO_4$, at several stages of growth and as a result of a field experiment, reported that $(NH_4)_2SO_4$ increased the Mg concentration in barley plants more than $NaNO_3$, at 4 stages of growth.

Several workers (Hemingway, 1960a, 1960b and 1961a; Todd, 1961a; Hunt et al., 1964) have reported increases in the Mg concentration of plants with $(NH_4)_2SO_4$ when it was the only source of applied N.

Hemingway reported that $(NH_4)_2SO_4$, compared with no-applied N increased the Mg concentration in grass, clover, and the leaves and stems of kale but had no effect on the concentration in the leaves and roots of turnips.

In a pot experiment with different grasses and clovers, Todd (1961a) found that $(NH_4)_2SO_4$, compared with no-applied N, increased the Mg concentration in clover at each cut, but increased grass Mg at the first cut only.

On increasing the rate of application of N, as $(NH_4)_2SO_4$, from 30 to 60 lb N per acre, Hunt et al. (1964) reported that the Mg concentration in herbage was increased.

Observing that less than 2 cwt per acre $(NH_4)_2SO_4$ sometimes caused Mg-deficiency symptoms in pine seedlings to disappear, and that higher rates intensified the symptoms, Will (1961) postulated that if the lower rates of $(NH_4)_2SO_4$ are nitrified quickly, the observed beneficial effects must be due to NO_3-N. Alston (1966a) supported this theory with results from a pot experiment; oat plants were grown to the 4- or 5- leaf stage in a Mg-deficient sand of pH 4.6. $(NH_4)_2SO_4$ reduced the Mg concentration in plants grown on the unlimed soil but generally increased the concentration when $CaCO_3$ was also added, whereas $Ca(NO_3)_2$ increased the Mg concentration in plants in both limed and unlimed soil.

(iii) K - Mg antagonism.

Although Ca and Mg are the major exchangeable bases in British soils and soils of cool, temperate regions, the concentration of K in plants is normally much greater than that of either Ca or Mg.

Dijkshoorn (1957), growing ryegrass in pots, containing a sandy soil, with increasing rates of N as the nitrates of K, Na, Mg or Ca, demonstrated that the increase in total basic cation concentration in the grass DM which occurred with increasing rate of N, was independent of the applied cation. However, the increase in cation concentration with either KNO_3 or $NaNO_3$ was due almost entirely to an increase of the applied cation. Because Mg and Ca themselves were not able to provide the required increase in cation uptake when increasing rates of either $Mg(NO_3)_2$ or $Ca(NO_3)_2$ were applied, the increased cation concentration was in those cations which were not supplied in the treatment. The author concluded that Ca and Mg were incapable of providing, at an adequate rate, this increased demand by grass for cations, as they are absorbed less readily than Na or K.

Van Itallie (1938) and York et al. (1954) demonstrated the effects of applied K on its own concentration in plant material and also on that of Mg. When the carbonates of K, Ca, Mg and Na were applied at equivalent rates to acid soils of low percentage base saturation, van Itallie found that applied K was the cation most readily absorbed by ryegrass, that it had a greater depressing effect on the Mg concentration in grass DM than the other cations, and finally that it was able to replace some Ca and Mg in the grass. York et al., who grew lucerne, maize and Sudan grass in a silt loam with different levels of lime and potassium (sodium was also applied when lucerne was the test crop), reported that the concentration of K in plants was not influenced to any extent by the other cations and was mainly a function of

the 'available' K supply. However, an increase in available K greatly reduced the absorption of Mg.

Cain (1948) remarked that the order of effectiveness of applied Ca, Mg or K in reducing the concentration in plant material of the remaining two cations was the same as the order of their ionic mobilities viz. K > Mg > Ca.

After a study of the magnesium supplying power of twenty New Jersey soils, Prince et al. (1947) concluded that the most important single factor influencing the Mg uptake of the plants studied in the investigation was the quantity of 'available' K; the Mg concentration in plant DM being inversely proportional to the quantity of 'available' K. The literature contains very many references to the reduction in Mg concentration in plants resulting from an increase in the 'available' K supply, and only a small representative proportion of the total has been included in this section.

Walsh and Clarke (1944), from a study of Mg deficiency symptoms in tomatoes, showed that these were induced by heavy dressings of K. When K with anions other than SO_4 were used and compared with K_2SO_4, either the onset of the symptoms was retarded or the severity of the symptoms was reduced. This was reflected in the Mg concentration in the foliage: the K_2SO_4 reduced the Mg concentration to a greater extent than an equivalent rate of other K salts. Hunter (1946) also commented on this effect of K_2SO_4.

After further work, Walsh and Clarke (1945) concluded that the severity of Mg-deficiency symptoms in tomatoes was governed more by the K : Mg ratio in the foliage than the absolute concentration of Mg in the plant. Working with one-year old apple trees in sand and using nutrient solutions to supply varying quantities of Ca, Mg and K, Cain (1948) found that

Mg-deficiency symptoms were associated with a low Mg and a high K concentration in the leaves of Mg-deficient plants. He concluded that the 'apparent', Mg-deficiency symptoms might also be a toxicity effect from excess K.

Work on Mg deficiency in apple trees, reported by Boynton and Burrell (1944), suggests that the K - Mg antagonism is the result of a replacement of exchangeable soil-Mg with applied K. The resulting higher exchangeable K : Mg ratios were conducive to the development of Mg-deficiency symptoms. Hogg (1960) reported considerable losses of soil Mg by leaching as a result of applications of KCl. Although a decrease in exchangeable Mg may result from an application of K this is not the major reason for the antagonism, as the results of investigations by Walsh and O'Donohoe (1945), into the problem, show.

These workers (a) studied the effects of increasing rates of K (low, medium and high), as K_2SO_4, on potatoes, tobacco, sugar beet and cereals grown in pots in a sand-peat mixture (b) carried out field experiments with potatoes using increasing rates of K_2SO_4 and (c) examined the soils from sites where Mg-deficiency symptoms had appeared.

(a) The results of the pot experiments indicated that the severe Mg-deficiency symptoms which occurred in the foliage of potatoes, tobacco and sugar beet were caused by the high levels of applied K which had induced in the foliage a much lower concentration of Mg than occurred in healthy plants. In these experiments wheat showed no Mg-deficiency symptoms and barley only a mild form with rates of K similar to those which had produced symptoms in the other crops.

(b) When 5 cwt per acre K_2SO_4 were applied to a soil with exchangeable K and Mg concentrations of 28 and 156 mg per 100 g soil respectively severe

Mg-deficiency symptoms developed in the foliage of potatoes and these were associated with a low Mg concentration. As a result of this Mg deficiency the yield of tubers and their uptake of Mg was lower at 5 than at 2 cwt K_2SO_4 per acre.

(c) Walsh and O'Donohoe found that soil samples, from sites where Mg-deficiency symptoms appeared in plants, were never 'deficient' in Mg but consistently had large quantities of exchangeable K.

These workers concluded that the relative amounts of 'available' soil K and Mg were of greater importance in determining the availability of Mg to plants than the absolute amount of 'available' Mg.

The Mg concentration in the foliage of potatoes and cereals was found to be lower in plots receiving higher rates of K: potatoes (Nicholas and Catlow, 1947; McNaught, 1959; Howland and Caldwell, 1960); cereals (Schreiber, 1949; Ferrari and Sluijsmans, 1955; Foy and Barber, 1958; Holmes, 1962b; Thompson, 1962). Many workers including Stewart and Holmes (1953); Hunt et al. (1964); Mudd et al. (1967) have attempted to relate the decrease in herbage Mg in grassland, from applied K, with the incidence of hypomagnesaemia, but Reith (1963) concluded that, although excessive rates of K would depress herbage Mg, rates which were just sufficient to maintain yields would have little effect on it.

In his paper, Reith (1963) presents a brief review of the literature on critical levels of 'available' soil Mg. Most workers suggested a critical level of between 2 and 5 mg Mg per 100 g soil. Salmon (1963) in a review article was extremely critical of existing methods of assessing the 'availability' of soil Mg and the remainder of this review deals with the chemical methods developed by Salmon and Arnold for assessing 'availability'.

'Availability' of soil Mg

Salmon and Arnold (1963), after growing Perennial ryegrass or White Clover in a range of soils for up to 11 months, found that the uptake of Mg + residual exchangeable Mg was closely correlated (r = 0.99) with the initial exchangeable Mg concentration. However, the Mg concentration and uptake at the first cut was poorly correlated with the initial exchangeable Mg concentration. It is possible that the continuous cropping technique had reduced the exchangeable K concentration in soils where it was high, thereby reducing the K - Mg antagonism, so that a compensation effect on Mg uptake occurred with time. The conclusion of these workers from this investigation that 'available' Mg was related to the exchangeable fraction was supported by Michael and Schilling (1957) who, growing flax in pots, showed that Mg uptake took place from the small amount of exchangeable soil Mg.

As a result of a later experiment (Salmon 1964), in which Perennial ryegrass was grown on two soils: each soil having 4 exchangeable K concentrations and 4 exchangeable Ca:Mg ratios, Salmon (1964) derived a relationship (r = 0.99) between the Mg concentration in the ryegrass after 5 weeks and the following ion-activity ratio:-

$$\frac{\sqrt{a_{Mg}}}{\sqrt{a_{Ca+Mg}} + B \cdot a_K} .$$

The factor B depends on the properties of the plant used: it expresses the relative ability of Ca and Mg to compete with K.

After cropping a range of soils with different pH values and exchangeable Mg, Ca, K concentrations Salmon (1964) obtained an excellent relationship (r = 0.99) between the Mg concentration in ryegrass at 5 weeks and the following

ion-activity ratio:-

$$\frac{\sqrt{a_{Mg}}}{\sqrt{a_{Ca+Mg} + B \cdot a_K + C \cdot a_H}} \quad .$$

This expression takes account of the effects of both pH and K on the availability of soil Mg. (C is a proportionality factor for pH).

Although Salmon and Arnold (1963), in their greenhouse experiment, obtained uptakes equivalent to between 100 and 200 lb Mg per acre, agricultural crops in the field remove much less (Salmon, 1963).

III. EXPERIMENTAL METHODS AND MATERIALS

A. ANALYTICAL METHODS.

1. PLANT ANALYSIS.

The reliability of each of the proposed methods of plant analysis was first tested, either by the direct comparison of results from the proposed method with those from an accepted method, or by the use of the recovery technique.

Preparation of samples for analysis.

The method of sampling plant material in the field and the quantity taken for dry matter determinations, botanical and chemical analyses were specific for the crop examined. These techniques will be described in more detail later.

The representative sample of plant material was dried overnight at 95°C, ground in a Christy and Norris mill and stored in bottles till required for analysis. All digestions and determinations were carried out in duplicate.

Determination of total N.

The Kjeldahl method works well for the determination of N in proteins, amines and amides, but in the presence of large quantities of nitrates there is some loss of N as HNO_3 (p. 28). If salicylic acid is added with the conc H_2SO_4 (Vogel, 1955), before digestion, the HNO_3 is fixed as nitro-salicylic acid, which is reduced to the amino compound on the addition of sodium thiosulphate. The amino compound is broken down, along with the complex nitrogenous compounds in plant material, to $(NH_4)_2SO_4$ by the conc H_2SO_4.

Reagents:-

Sulphuric acid - salicylic acid reagent.

83 g salicylic acid ($C_6H_4(OH)COOH$) dissolved in 2.5 l conc H_2SO_4.

50% (w/v) NaOH (technical grade).

0.0714N H_2SO_4 in distilled water.

4% (w/v) boric acid (H_3BO_3) in distilled water (20 ml 4% H_3BO_3 will retain 40 mg N).

K_2SO_4

Sodium thiosulphate, $Na_2S_2O_3.5H_2O$.

$CuSO_4.5H_2O$.

Zinc (granulated).

Mixed indicator.

Mix equal volumes 0.2% (w/v) alcoholic methyl red and 0.1% (w/v) aqueous methylene blue.

Procedure:-

1 g oven-dry plant material was placed in a 500 ml Kjeldahl digestion flask. 25 ml sulphuric acid - salicylic acid reagent were added and the flask shaken immediately to mix the contents, and then at intervals during 10 to 15 min; the flask being kept cool throughout this period. 5 g K_2SO_4 and 2.5 g $Na_2S_2O_3.5H_2O$ were then added followed by a crystal of $CuSO_4.5H_2O$ to act as catalyst. The contents were heated fairly strongly until the organic matter was decomposed and the contents were colourless; and then for a further 1.5 h. When the flask had cooled, 210 ml distilled water and a small piece of granulated zinc were added. After excess 50% NaOH had been added (1 ml conc H_2SO_4 ≡ 2.9 ml 50% NaOH) the NH_3 was distilled into 20 ml 4% H_3BO_3 plus 100 ml distilled water. Distillation was continued for 30 min. The quantity of NH_3 in the H_3BO_3 was determined by direct titration against 0.0714N H_2SO_4 using the mixed indicator. A 'reagent blank' determination was carried out periodically. For 1 g dry matter a titration of 1 ml 0.0714N H_2SO_4 = 0.1% N in the dry matter.

Wet ashing and preparation of plant extract for the determination of Mg, K and P.

Most ions are obtained in solution in the excess acid at the completion of a wet ashing, and complex silicates are not formed since

the temperature should never exceed the boiling point of the 'acid mixture'. For these reasons and also for the speed and ease of operation a wet ashing is preferable to a dry one.

Reagents:-

Acid mixture.

1,200 ml conc HNO_3, 200 ml H_2SO_4 and 100 ml (60% w/w) $HClO_4$.

Procedure:-

1.25 g oven-dry plant material were placed in a 100 ml Kjeldahl digestion flask, which had been previously calibrated at 125 ml. 15 ml acid mixture were then added (Piper, 1950) and the contents heated very gently until fumes of $HClO_4$ appeared. Digestion was continued, at a low heat, for a further 5 to 10 min then the heating was increased and continued for a further 5 min. when the digest consisted of only H_2SO_4 plus plant remains. When cool, distilled water was added and the volume made to 125 ml. The insoluble material was allowed to settle and aliquots of the supernatant liquid, solution A, were taken for the different analyses.

Determination of Mg.

A reliable method for the determination of Mg in plant material was developed by Young and Gill (1951) using the colour reaction of Mg with titan yellow in alkaline medium. Poor sensitivity in this method can be due to the titan yellow reagent. Variations in sensitivity were found between different sources of titan yellow, and also between different batches from the same source (p. 29).

The colour produced in the reaction between titan yellow and Mg is stabilized with polyvinyl alchol and interferences elimated or compensated for by the addition of hydroxylamine hydrochloride ($NH_2OH.HCl$) and a compensating solution.

Reagents:-

Compensating solution.

1.263 g $CaCO_3$
0.35 g $Al_2(SO_4)_3.16H_2O$
0.21 g $MnSO_4.4H_2O$
0.25 g $FeSO_4.7H_2O$
0.059 g $CuSO_4.5H_2O$
0.70 g $Na_3PO_4.12H_2O$

These salts were dissolved in about 700 ml distilled water and 7 to 8 ml conc HCl. When solution was complete the volume was made to 1 l with distilled water.

2% (w/v) Polyvinyl alcohol (PVA).

2 g PVA were dissolved, by heating gently, in 100 ml distilled water, filtered if not clear, and, when cool, stored in a refrigerator.

1% (w/v) Hydroxylamine hydrochloride, $NH_2OH.HCl$, in distilled water.

Mixed reagent

Equal volumes of the first three reagents were mixed just before use.

0.02% (w/v) Titan Yellow (Eastman Kodak Co.) in distilled water, prepared fresh daily.

10N NaOH.

Standard Mg solutions.

(i) Stock solution, 500 ppm Mg.

1.2375 g anhydrous $MgSO_4$ (prepared by heating $MgSO_4.7H_2O$ at 300°C until constant weight was obtained, i.e. after about 7 h) were dissolved in distilled water, 18 ml N HCl added to prevent fungal growth, and the volume made to 500 ml.

(ii) Working standard solution, 10 ppm Mg.

10 ml of (i) were diluted to 500 ml with distilled water.

(iii) Range of standard solutions.

A range of standard solutions, containing 0.5, 1, 2, 3 and 4 ppm Mg, was prepared by diluting 5, 10, 20, 30 and 40 ml of (ii) to 100 ml with distilled water.

Procedure:-

A 1 in 10 dilution of the original plant extract (5 ml solution A, (p. 21), made to 50 ml with distilled water) was made, and this is designated solution B. A 5 ml aliquot of solution B, containing less than 20 µg Mg, was placed in a 6 in. x 1 in. (150 mm x 25 mm) Pyrex boiling tube. At the same time 5 ml distilled water ('reagent blank') and 5 ml aliquots of each of the range of standard solutions, (iii), were placed in similar boiling tubes.

To each tube in turn, 3 ml mixed reagent were added, followed quickly by 1 ml titan yellow solution and 2 ml 10 N NaOH. The contents were thoroughly mixed after the addition of each reagent, and, after the addition of the 10 N NaOH, the tubes were allowed to stand for exactly 10 min, before the colour intensities were read on a portable EEL colorimeter using Ilford filter 624 (540 mµ), setting the instrument to zero with distilled water.

The addition of the 3 reagents, required for colour development takes less than 1 min. Colour can be developed in 10 tubes in 10 min. by which time the colour intensity of the first tube can be read and the others thereafter a 1 min. intervals.

A 5 ml aliquot of the maximum standard (4 ppm Mg) is equivalent to 0.4% Mg in the dry matter of plant material when a 5 ml aliquot of solution B is used.

Determination of K.

K was determined in solution B, (p.23), by using an EEL flame photometer (Collins and Polkinhorne, 1952).

Reagents:-

Standard K solutions.

(i) Stock solution, 1000 ppm K.

1.7405 g oven dry KH_2PO_4 were dissolved in distilled water, 2 or 3 drops chloroform added to prevent fungal growth, and the volume made to 500 ml with distilled water.

(ii) Working standard solution, 250 ppm K.

Dilute 25 ml of (i) to 100 ml with distilled water.

(iii) Range of standard solutions.

A range of standard solutions containing 5, 10, ... 50 ppm K was prepared by diluting 1, 2, ... 10 ml of (ii) to 50 ml with distilled water.

Procedure:-

The maximum standard (50 ppm K) was used for setting the instrument to 100, and is equivalent to 5% K in the dry matter of plant material when solution B is used.

Determination P.

The molybdenum-blue method of Fiske and Subbarow (1925), modified by Yuen and Pollard (1951), was used to determine P in plant material. While less sentitive than Denigès' (Atkins, 1924) and more sensitive than Hanson's (1950), Yuen and Pollard's method is more suited for determining the amounts of P commonly found in plant material.

Reagents:-

8.5N H_2SO_4.

232 ml conc H_2SO_4 were dissolved in about 600 ml distilled water. When cool, the volume was made to 1 l with distilled water.

2.5% (w/v) Ammonium molybdate ($(NH_4)_6Mo_7O_{24}.4H_2O$) reagent.

2.5 g $(NH_4)_6Mo_7O_{24}.4H_2O$ were dissolved in 100 ml 8.5N H_2SO_4.

1-Amino-2-naphthol-4-sulphonic acid reagent (A.N.S.A.).

0.2 g 1-amino-2-naphthol-4-sulphonic acid (extra pure), 5 g sodium metabisulphite, $Na_2S_2O_5$, and 2 g sodium sulphite, $Na_2SO_3.7H_2O$, were dissolved in water and the volume made to 100 ml. This solution should not be kept for longer than 3 weeks.

Standard P solutions

(i) Stock solution, 500 ppm P.

2.1964 g oven-dry KH_2PO_4 were dissolved in distilled water, 2.5 ml conc H_2SO_4 were added to prevent fungal growth, and the volume was made to 1 l with distilled water.

(ii) Working standard solution, 25 ppm P.

25 ml of (i) were diluted to 500 ml with water.

Procedure:-

5 ml original plant extract, i.e. solution A (p. 21), containing not more than 250 µg P, were placed in a 6 in. x 1 in. (150 mm x 25 mm) Pyrex boiling tube, graduated at 50 ml. At the same time 0, 1, 2.... 10 ml working standard solution, containing 0, 25, 50 ..... 250 µg P, were placed in similar tubes. The volume in each tube was made to about 45 ml with distilled water. 2 ml ammonium molybdate reagent were added and then, after shaking, 1 ml A.N.S.A. reagent.

The contents were again shaken after the volume had been made to 50 ml with distilled water. The colour intensities were measured on a portable EEL colorimeter, at any time between 12 and 40 min after final mixing, using Ilford filter 608 (680 mμ) and setting the instrument to zero with distilled water.

The maximum standard, containing 250 μg P, is equivalent to 0.5% P in the dry matter of plant material when a 5 ml aliquot of solution A is used.

Determination of Ca.

P interferes in the flame-photometric determination of Ca by suppressing the Ca emission. It had been intended to determine Ca by the technique of Williams and Morgan (1953), which involves the precipitation of Ca as the oxalate in centrifuge tubes, the removal of P in the supernatant solution by decantation and the direct determination of the Ca concentration in dilute acid on the flame photometer. Although there was good agreement between results by this method and by the classical oxalate-permanganate one it was felt that the flame-photometric method was unsuitable for the routine analysis of plant samples. The EEL flame photometer is less satisfactory for Ca than for K or Na (a minimum of 100 ppm Ca is required for maximum setting of the instrument compared with 10 ppm K and 5 ppm Na), and there were occasions when duplicates did not agree. It was, therefore, decided to use the longer, but more reliable, oxalate-permanganate method (A.O.A.C., 1960), in the one experiment where Ca was determined.

Reagents:-

Conc HCl.

Saturated ammonium oxalate solution.

0.5% (w/v) Methyl red.

0.5 g methyl red dissolved in 100 ml alcohol.

Ammonia solution (s.g. = 0.88).

Dilute NH_4OH.

1 volume ammonia solution (s.g. = 0.88) added to 4 volumes distilled water.

7N H_2SO_4.

1 volume conc H_2SO_4 added to 4 volumes distilled water.

0.1N $KMnO_4$.

Procedure:-

(a) Ashing and solution of Ca.

4 g oven-dry plant material were ignited in a silica basin until the resulting ash was greyish white or grey and contained only small amounts of unburnt carbon. A small amount of distilled water was added to moisten the ash, followed carefully by 5 ml conc HCl. The contents were evaporated to dryness on a steam bath, and then for a further 1 h to dehydrate the silica. The residue was moistened with distilled water and 5 ml conc HCl. After heating on the steam bath for 2 min, 20 ml hot water were added, and the solution filtered through a Whatman No. 44 paper, collecting the filtrate in a 200 ml beaker. The residue on the silica basin and filter paper were washed thoroughly with hot distilled water until 50 to 60 ml leachate had been collected.

(b) Precipitation and determination of Ca

After the filtrate, in the 200 ml beaker, had been heated at boiling point with 10 ml of saturated ammonium oxalate solution and

allowed to cool the pH of the supernatant liquid was adjusted to 5.0 (faintly pink with 2 drops 0.5% methyl red solution) by the addition of first conc and then dilute ammonia solutions. The precipitate and supernatant liquid were filtered on a Whatman No.44 after 4 h, washing the precipitate with a small amount of distilled water until the filtrate was free from oxalate. A hole was pierced in the apex of the filter paper with a sharp-pointed glass rod and the precipitate was washed through this hole with a strong jet of water and 10 ml 7N H_2SO_4, into the beaker in which the precipitation had taken place. Titration against 0.1N $KMnO_4$ was carried out at 90°C, in the beginning without, but finally in the presence of the filter paper.

1 ml 0.1N $KMnO_4$ is equivalent to 0.05% Ca when 4 g plant material are used.

Reliability of Methods and Reproducibility of the Results.

Nitrogen.

The proposed method (p. 19), Method A, was compared with another Kjeldahl method, Method B, in which there was no attempt to 'trap' nitrate N. Either 10 or 20 mg N, as KNO_3, were added to 1 g sucrose or to 1 g dried grass, and the quantity of N recovered by each of these 2 methods was determined.

Material.	NO_3-N added(mg).	NO_3-N recovered(mg).		Per cent recovery.	
		A	B	A	B
Sucrose	10	10.1	7.4	101.0	74.0
Sucrose	20	19.8	12.4	99.0	62.0
Dried Grass	10	9.7	8.4	97.0	84.0
Dried Grass	20	19.5	13.9	97.5	69.5

The proposed method, Method A, gave a satisfactory recovery of NO_3-N from both the sucrose and the dried grass and more than 60% was recovered by Method B. (In another experiment 9.9 mg N were recovered, by the

latter method, from 10 mg N, as KNO_3, in the presence of 25 mg N, as acetanilide.)

Amounts of KNO_3, providing from 5 to 25 mg N, were added to 1 g sucrose and the amount of N, at each level of application, was determined by the proposed method. The recoveries of added N were as follows:-

NO_3-N added(mg).	NO_3-N recovered(mg).	Per cent recovery.
5	5.1	102.0
10	10.1	101.0
15	15.0	100.0
20	20.0	100.0
25	24.9	99.6

The concentrations of 'total N' in ten 1 g aliquots of a dried grass were determined by the proposed method and the mean, standard deviation and co-efficient of variation of these results were 2.77% N, ± 0.0226 and 0.82% respectively.

Magnesium.

It was discovered that 2 batches of titan yellow (spot test reagent) from B.D.H. Ltd. were unsatisfactory for the quantitative determination of Mg, even although this reagent had been recommended for this purpose by the manufacturers. The calibration curves, relating Mg concentration with colorimeter reading, for the unsatisfactory B.D.H. titan yellow and for the reliable material used in this investigation (Eastman Kodak Co.) are presented in Fig. 1.

The results by the proposed method, of the analysis of 8 different plant materials, were compared with those from a gravimetric estimation (Piper, 1950), in which after removal of Ca as the oxalate the Mg was

precipitated as $MgNH_4PO_4.6H_2O$ and later ignited to $Mg_2P_2O_7$:-

Plant Material	Per cent Mg in dry matter. Proposed Method.	Gravimetric Method.
1. Maize.	0.168	0.168
2. Oat leaves.	0.098	0.103
3. Marrow stem kale.	0.185	0.191
4. Clover.	0.426	0.422
5. Grass.	0.113	0.116
6. Wheat Grain.	0.108	0.111
7. Turnip root.	0.085	0.084
8. Rape.	0.184	0.188

Potassium

The reliability of the K method was assessed by the recovery technique; 32 mg K (as KCl) were added to 1 g of each of the above 8 plant materials:-

	K in plant material	K in plant material + K recovered	K recovery	Per cent recovery
	mg	mg	mg	
1. Maize.	18.4	51.0	32.6	101.9
2. Oat leaves.	19.4	51.3	31.9	99.7
3. Marrow stem kale.	26.9	60.0	33.1	103.4
4. Clover.	9.3	40.8	31.5	98.4
5. Grass.	18.2	50.4	32.2	100.6
6. Wheat Grain.	4.1	35.8	31.9	99.7
7. Turnip root.	22.5	55.0	32.5	101.6
8. Rape.	26.0	58.6	32.6	101.9

Phosphorus.

The results, by the proposed method of analysis (1), were compared with those obtained by the Lorenz gravimetric method (2) (Piper, 1950) and by Hanson's (1950) colorimetric method (3) :-

	Per cent P in dry matter.		
Plant Material.	Method (1)	Method (2)	Method (3)
1. Maize.	0.216	0.210	0.218
2. Oat leaves.	0.300	0.291	0.302
3. Marrow stem kale.	0.271	0.260	0.272
4. Clover.	0.267	0.258	0.270
5. Grass.	0.270	0.260	0.273
6. Wheat grain.	0.326	0.317	0.326
7. Turnip root.	0.394	0.381	0.393
8. Rape.	0.333	0.319	0.332

Calcium

The results, by the proposed method of analysis (A.O.A.C., 1960), were compared with those obtained by the flame-photometric method of Williams and Morgan (1953):-

	Per cent Ca in dry matter.	
Plant material	Proposed method.	Flame-photometric method.
1. Maize.	0.32	0.31
2. Oat leaves.	0.30	0.30
3. Marrow stem kale.	0.85	0.82
4. Clover.	2.60	2.54
5. Grass.	0.38	0.38
6. Wheat Grain.	0.05	0.06
7. Turnip root	0.36	0.34
8. Rape.	0.95	0.95

Combined Sampling and Analytical Errors.

In order to determine the combined sampling and analytical errors for each element and also for the dry matter estimation, 10 representative herbage samples were taken from one plot of each of 2 grass experiments:-

	Mean (per cent)		Standard deviation		Coefficient of variation (per cent)	
	Expt. 1.	Expt.2.	Expt.1. ±	Expt.2. ±	Expt.1. ±	Expt.2. ±
Dry matter	27.2	24.1	0.276	0.316	1.01	1.31
N	1.72	2.36	0.0376	0.0135	2.18	0.57
Mg	0.207	0.290	0.00498	0.00956	2.41	3.30
K	2.06	1.29	0.0436	0.0342	2.11	2.65
P	0.308	0.408	0.00263	0.00492	0.85	1.21
Ca.	0.56	0.60	0.0242	0.00895	4.29	1.49

2. SOIL ANALYSIS.

Method of sampling and preparation of sample.

Soil samples were taken with a screw-type auger which sampled the 0 to 8 in. (20 cm) layer of top soil. Samples contained 14 cores taken at random from the experimental area. When air-dry, the large soil particles were broken down in a Rukuhia-type grinder (Waters and Sweetmen, 1955) and the material passing the 2 mm round-hole sieve was retained for analysis.

pH.

The pH of the suspension of soil in distilled water (the ratio of soil to water was 1: 2.5, weight : volume) was measured on a PYE pH meter using a glass electrode and a calomel half-cell fitted with a flushing device for exposing a fresh surface of saturated KCl solution to each soil.

Determination of exchangeable Ca, Mg and K.

(a) Preparation of soil extract.

Reagents:-

2N NH_4OH.

108 ml conc ammonia solution (s.g. 0.88) were diluted to 1 l with distilled water. This solution was standardized against acid using methyl red as indicator, and if necessary adjusted to a normality of 2.

2N CH_3COOH.

115 ml glacial acetic acid were diluted to 1 l with distilled water. This solution was standardized against alkali using methyl red as indicator, and if necessary adjusted to a normality of 2.

N CH_3COONH_4.

Equal volumes of the above solutions were combined. The pH (measured on a pH meter) of the resulting solution was adjusted to 7.0, if necessary, by the addition of either 2N CH_3COOH or 2N NH_4OH.

Procedure:-

5 g air-dry soil were placed in a 100 ml beaker along with 20 ml neutral N CH_3COONH_4. The mixture was stirred and allowed to stand overnight covered with a watch glass. It was then transferred completely to a Whatman No. 30 paper and the leachate was collected in a 500 ml volumetric flask. A further 230 ml N CH_3COONH_4, added in small amounts of 40 to 50 ml at each addition, were used for complete removal of the exchangeable bases. When leaching was complete the volume was made up to 500 ml with distilled water. The solution was now approximately 0.5N with respect to CH_3COONH_4.

(b) Determination of Ca, Mg and K in the leachate.

The concentrations of Ca, Mg and K, in the leachates, were determined on the Unicam SP 900 flame spectrophotometer using methods developed in the Spectrochemistry Department of the Edinburgh School of Agriculture (Purves, 1966). The emission technique was used for Ca and K, and Mg was determined by atomic absorption .

Reagents:-

(A) Stock Ca solution, 4,000 ppm Ca.

9.90 g $CaCO_3$ were dissolved in 200 ml N HCl and the volume was made up to 1 l with distilled water.

(B) Stock K solution, 400 ppm K.

0.762 g KCl were dissolved in distilled water and the volume made to 1 l.

(C) Stock Mg solution, 800 ppm Mg.

8.10 g $MgSO_4 . 7H_2O$ were dissolved in distilled water and the volume made to 1 l.

(D) Working standard solution for Ca and K, containing 80 ppm Ca and 8 ppm K.

20 ml solution (A) and 20 ml solution (B) were pipetted into a 1 l volumetric flask and the volume was made to the mark with 0.5N CH_3COONH_4.

(E) Range of standard solutions for Ca and K.

A range of standard solutions was prepared by diluting 5, 15, 25, 50, 75 and 100 ml of solution (D) to 200 ml with 0.5N CH_3COONH_4. The concentrations of Ca and of K in these solutions and their equivalent concentrations in soil (5 g soil ≡ 500 ml) are given in the following table :-

Ca in solution (ppm)	2	6	10	20	30	40
Ca in soil (mg/100g)	20	60	100	200	300	400
K in solution (ppm)	0.2	0.6	1	2	3	4
K in soil (mg/100g)	2	6	10	20	30	40

(F) Working standard solution for Mg, containing 16 ppm Mg.

20 ml solution (C) were diluted to 1 l with 0.5N CH_3COONH_4.

(G) Range of standard Mg solutions.

A range of standard solutions was prepared by diluting 5, 15, 25, 50, 75 and 100 ml of solution (F) to 200 ml with 0.5N CH_3COONH_4. (Each standard solution contained 10 ppm Ca in the final volume).

The concentrations of Mg in these solutions and their equivalent concentrations in soil are given in the following table:-

Mg in solution (ppm)	0.4	1.2	2	4	6	8
Mg in soil (mg/100g)	4	12	20	40	60	80

Procedure:-

Calibration curves for Ca and for K were constructed by plotting, on graph paper, galvanometer reading against appropriate concentration.

In constructing the calibration curve for Mg, determined by atomic absorption, log $^{100}/_{d}$ (where d = galvanometer reading and 100 = reading with 'blank' solution) was plotted against concentration.

The concentrations of exchangeable Ca, Mg and K in soil were read directly from the appropriate calibration curve.

B. FIELD EXPERIMENTS.

The effects of fertilisers, containing N, P, K and Mg, on the yield and chemical composition of 3 agricultural crops, viz. grass (including clover), barley and potatoes, were investigated in field experiments, between 1960 and 1967.

For convenience, these experiments have been numbered and identified as follows:-

I. GRASSLAND.

(i) NKMg (3 sites).

(ii) Mg compounds (1 site).

II. BARLEY.

(i) NKMg (1 site).

III. POTATOES.

(i) NPKT (1 site).

(ii) KTMg (1 site).

The 3 sites in the NKMg series on grassland were selected at random; there being no attempt to select sites with soils having a low exchangeable-Mg content (less than 5 mg Mg per 100 g soil). The sites for all other experiments were selected because of their association with a Mg deficiency, either in crops or animals. In all experiments, fertilisers were applied by hand.

I. GRASSLAND

(i) NKMg (3 sites)

The immediate and long-term effects of N ($(NH_4)_2SO_4$), K (KCl) and Mg ($MgSO_4$), individually and in combination, on the yield and chemical composition of herbage, were studied in 3 similar experiments which were started in 1960 (spring) and concluded in 1965. At each site there were 2 replicates of a 2 x 2 x 2 factorial design.

Sites:-

(a) Kingside Farm, Peeblesshire (elevation 900 ft).

(b) Sharplaw Farm, Roxburghshire (elevation 400 ft).

(c) Glendeuglie Farm, Perthshire (elevation 600 ft).

The 'grass-break', in the rotation of each of these farms, lasts for 6 or 7 years and the seeds-mixture contains the following grass seeds: Perennial Ryegrass, Cocksfoot, Timothy, Rough-stalked Meadow-grass; Red and White Clover are also included. In 1960, sites (a) and (b) were first-year, grass swards and site (c) was a second-year sward.

The 2 levels of each of the 3 nutrients N, K and Mg were 0 and 1, i.e. not-applied and applied, which individually and in combination gave the following 8 treatments:- (1), Mg, N, NMg, K, KMg, NK and NKMg. (where (1) represents $N_0K_0Mg_0$).

A split-plot design was used; Mg was applied to sub-plots, and N and K to main plots. The area of each sub-plot was 0.01 acre (sub-plots will now be referred to as plots); the plot dimensions at sites (a) and (b) were 32.25 ft x 13.5 ft and at site (c) 24 ft x 18 ft. Treatment randomizations and dimensions, for each of the 3 sites, are given in Fig. 2. The experimental area, 0.16 acres, at each site, was fenced.

The pH value, exchangeable K and Mg, and the 'easily-soluble' P contents were determined on soil samples taken from each site just before the fertiliser treatments were applied in 1960. These values, along with soil textures, are given in Table 1. Exchangeable calcium was included in the analyses of the soil samples taken in December 1964,

from each plot at each site.

Table 1. Soil data for experiment I (i) (samples taken spring, 1960).

	(a) Kingside.	(b) Sharplaw.	(c) Glendeuglie.
Texture.	Sandy clay loam.	Sandy loam, stony.	Loam.
'Easily-soluble' P[1]	0.12	0.97	0.22
Exchangeable K[1]	9.1	5.6	9.8
Exchangeable Mg[1]	7.8	4.9	11.8
pH	6.1	6.4	6.1

$(NH_4)_2SO_4$ (21% N), KCl (50% K) and $MgSO_4$ (20% Mg) were used as the source of N, K and Mg respectively. At all sites in 1960, 1961 and 1962 and site (c) in 1963, the following rates of these nutrients were applied in the spring of each year, in one application:-

80 lb N per acre, 100 lb K per acre and 90 lb Mg per acre.

In 1963 at sites (a) and (b) the total amount of N and of K applied, in lb per acre, was 120 and 125 respectively, in addition to 90 lb Mg per acre. The N and K were applied in 3 dressings which, per acre were:-

60 lb N and 75 lb K in the spring and

30 lb N and 25 lb K after the first and second cuts.

All the Mg was applied in the spring.

No Mg was applied in 1964, but 60 lb N and 75 lb K at sites (a) and (b) and 80 lb N and 100 lb K at site (c) (all per acre) were applied, in one application, in the spring.

A basal dressing, equivalent to 26 lb P per acre, as triple-superphosphate, was applied annually to all plots.

Fertilisers were not applied in 1965.

1. mg per 100 g soil.

The dates of fertiliser application and the amounts applied are given, in detail, in Table 2.

Table 2. Dates of fertiliser application and amounts applied for experiment I (i).

	lb per acre			Date of application		
Year	N	K	Mg	(a) Kingside.	(b) Sharplaw.	(c)Glendeuglie.
1960	80	100	90	16 April	21 April	4 April
1961	80	100	90	18 March	18 March	24 February
1962	80	100	90	5 March	5 March	24 February
1963	80	100	90	-	-	21 March
	60	75	90	23 March	23 March	-
	30	25	-	3 June	3 June	-
	30	25	-	23 July	23 July	-
1964	80	100	-	-	-	25 March
	60	75	-	10 April	10 April	
1965	-	-	-	-	-	-

The herbage was cut 2 or 3 times each year. The first cut was taken just before 'heading-out' of the grass, and an interval of about 7 weeks was allowed between cuts; the third cut was taken in September or October. The dates of cutting are given in Table 3.

Table 3. Dates of cutting experiment I (i).

	(a) Kingside. Cut.			(b) Sharplaw. Cut.			(c) Glendeuglie. Cut.		
Year	1	2	3	1	2	3	1	2	3
1960	27/5	29/7	23/9	30/5	29/7	26/9	1/6	14/7	5/9
1961	15/5	14/7	6/10	11/5	11/7	4/10	3/5	26/6	7/9
1962	1/6	18/7	24/9	1/6	18/7	21/9	17/5	28/6	24/8
1963	1/6	22/7	17/9	31/5	22/7	17/9	27/5	27/8	n.c.
1964	12/6	21/8	n.c.	9/6	28/8	n.c.	14/5	13/7	4/9
1965	11/6	16/7	n.c.	11/6	16/7	n.c.	15/5	31/8	n.c.

n.c. = no cut.

Method of cutting and sampling.

An 18 in. guard strip was cut on either side of all plot, boundary lines by 'lining-up' the centre of the cutter-bar (3 ft broad), of an 'Allen' motor scythe, with the boundary lines (Fig. 3). The cut grass was raked clear of the guard strips before the plots were cut. After cutting the plots (their harvested dimensions were 29.25 ft x 10.5 ft at sites (a) and (b) and 21 ft x 15 ft at (c)), and while the cut grass lay in orderly rows, about 500 g of fresh material were collected from each plot; small handfuls of herbage were lifted, at random, until the required amount had been gathered. After sampling, the yield (including sample) was measured on a 'Salter' spring balance (no yield measurements were made in 1965).

Before drying, the herbage samples from sites (a) and (b) were separated into grass and clover at all cuts in 1960 and the proportion of each fraction in the sample determined. The percentage dry matter and the concentrations of N, P, K and Mg in the dry matter of each fraction were determined. The 'mixed herbage' samples from site (c)

in 1960 and from all sites in subsequent years, were analysed, as above, without botanical separation.

(ii) Mg compounds.

This experiment was at Balfarg Farm (elevation 300'), Fife, where there had been a history of hypomagnesaemia in dairy cattle. Leys on this farm, are normally of 4 to 5 years duration, and this experiment was started in 1964 (spring) on a first-year, grass sward, with a botanical composition similar to those in experiment I (i). The farm manager wanted to know the most efficient and yet economical method of increasing the Mg concentration of grass on this farm and the following treatments were chosen in an attempt to answer the farm manager's questions:-

A No Mg.

B 60 lb Mg/acre as calcined magnesite.

C 120 lb " " " " "

D 300 lb " " " " "

E $MgSO_4 . 7H_2O$ (1).

F $MgSO_4 . 7H_2O$ (2).

G 60 lb Mg/acre as magnesium ammonium phosphate.

H 300 lb " " " magnesian limestone.

The above Mg compounds had the following chemical composition:-

Calcined magnesite (commerical grade) : 54.3% Mg.

Epsom salt : 9.3% Mg.

Magnesium ammonium phosphate, manufactured by S.A.I. Ltd.:

15.7% Mg; 9.0% N; 19.9% P.

Magnesian limestone from Steetley, Yorkshire : 11.4% Mg;

40% $Mg\ CO_3$; 55% $CaCo_3$.

A randomized block design was used; the 8 treatments being randomized in each of 4 replicates. Treatments B, C, D, G and H were applied once only, at the beginning of the experiment (17 March, 1964), but E and F were varied from year to year as follows:-

lb Mg/acre.

	17 March 1964.	30 March 1965.	4 April 1966.	12 April 1967
E	20	20	60	60
F	60	-	120	120

All treatments, except G and H, were mixed with a fine sand before application, to help make distribution easier and more uniform.

Each year, in the spring, a basal dressing of N, P and K was applied to each plot. The dates of application and the fertilisers used were as follows:-

Year	Fertiliser Rate	Per cent N.	P.	K.		
1964	3 5 cwt/acre of a fertiliser containing	18	4	7.5	applied	7 April.
1965	5 " " " " " "	13	5.5	17	"	30 March.
1966	6 " " " " " "	13	5.5	17	"	4 April.
1967	6 " " " " " "	13	5.5	17	"	12 April.

The total area per plot was 20 sq yd (2yd x 10yd), and the total experimental area, 640 sq yd , was completely enclosed by a fence. Treatment randomizations and dimensions are given in Fig. 4 (a).

Soil samples were taken from each plot on 16 March 1964, before the application of treatments and again on 5 January 1965, 3 March 1965, 4 April 1966 and 22 December 1966. Exchangeable Ca, Mg and K and pH

values were determined on all samples. The average values (of all plots) of these determinations at the first sampling, along with soil texture, were as follows:-

Texture	loam;	pH	6.2
Exchangeable	Ca	214 mg per 100 g soil.	
"	Mg	8.6 mg per 100 g soil.	
"	K	14.7 mg per 100 g soil.	

Method of cutting and sampling.

All plots were cut at least 3 times per annum. The dates of cutting were:-

	1964	1965	1966	1967
1	27 May	26 May	24 May	26 May
2	16 July.	20 July.	6 July.	21 July.
3	16 October.	23 August.	15 August	14 September.
4	-	23 September.	23 September.	-

In this grass experiment, guard strips, 3' wide, were removed from the 'top' and from the 'bottom' of each plot by running the outside edge of the motor scythe along the boundary line as shown in Fig.4 (b). After the grass had been removed from these strips an area 1 yd broad and 8 yd long was cut from the remainder of each plot by running the motor scythe along the middle, thus allowing a 18 in. guard strip between plots. The grass from the cut area (8 sq yd) was sampled, as in I (i) and then weighed (including sample).

Dry matter and the N, P, K, Ca and Mg concentrations in the dry matter were determined on all samples.

II (i) NKMg on BARLEY

In the spring of 1961 a manurial experiment with barley, was laid down at Damside farm (elevation 400'), Perthshire, in a field where, in the autumn of 1960, turnip leaves had shown Mg-deficiency symptoms; the exchangeable Mg content of the soil (sandy loam) was 2.1 mg per 100 g and the pH 7.2.

A 2 x 2 x 2 factorial design was used with complete randomization of all treatments within each of 3 replicates. The 2 levels of each of the 3 nutrients, N, K and Mg, were 0 and 1 and the 8 treatment combinations are represented by (1), N, K, NK, Mg, NMg, KMg and NKMg (where (1) represents $N_0K_0Mg_0$).

The rates of application and the fertilisers used were:-

N	-	40 lb/acre	-	$(NH_4)_2 SO_4$ (21% N).
K	-	50 lb/acre	-	KCl (50% K).
Mg	-	82 lb/acre	-	$Mg SO_4$ (20% Mg).

All plots received a basal dressing of 22lb P per acre as triple-superphosphate.

The individual plot area was 0.025 acres (14.5 ft x 75 ft); treatment randomizations and dimensions are given in Fig. 5 (a). Fertiliser treatments were broadcast before the seed (var. Ymer) was drilled at 2.7 bushels per acre on 22 March. Before and after application of treatments, the experimental area received the same cultivations as the remainder of the field.

Random plant samples, cut 3 in. above ground level, were taken from each plot on 7 July, before 'heading out'.

On 16 September, 2 days before the plots were harvested, a very strong wind removed about 50% of the grain from all plots; the loss appeared to be proportional to the 'expected' yield, from all treatments. The plots were cut with an 8.5 ft - wide combine harvester on 18 September, using a technique similar to that used in grass Experiment I (ii). A strip, 4.25 ft broad, was cut from the 'top' and from the 'bottom' of each plot by running the centre of the cutter-bar in line with the 'top' and with the 'bottom' boundary lines, Fig. 5 (b). An area 8.5 ft broad and 66.5 ft long (62.8 sq yd) was cut from the remainder of each plot by running the combine along the middle of the plot. The grain from each plot was collected in a sack; the weight of grain was measured and a representative sample (about 400 g) taken for analysis. A sample of straw was also taken from each plot.

Dry matter and the concentrations of N, P, K and Mg in the dry matter were determined on all samples.

III POTATOES.

The 2 potato experiments examined were designed and organized by Mr. R. Henderson, formerly of Potash Ltd. Mg-deficiency symptoms had appeared, in potatoes, at the sites of both experiments: (a) in the crop within the experimental area in the case of experiment III (i), and (b) in the year preceeding experiment III (ii) (1963), in potatoes grown in another field of the same farm.

The potatoes were grown for seed at both sites. This implies that the tubers were planted 9 to 12 in. apart (centre to centre) in the drills. Each drill was 27 in. broad, and a plot consisted of 6 adjacent drills, each 20 ft long, giving an area of 30 sq yd per plot.

The drills in the experimental area were 'opened' with a ridging plough and the plot corners were then marked with canes. Fertilizers were placed by hand, in narrow bands, in the bottom of each split-drill. Soil was gently raked on top of the fertilizer; the tubers were planted, above the fertilizer, and then covered with soil.

The experimental area received the same inter-row cultivations as the remainder of the field. After emergence, and before haulm growth was excessive, the drills were flattened with a tined cultivator, and left flat for one or two weeks, before being ridged up again. Haulms were destroyed, either mechanically or chemically, and harvesting was carried out 2 or 3 weeks after the date of haulm destruction.

The potatoes from the middle 4 drills by 14 ft were dug, by hand, i.e. there was a 3 ft guard strip at the 'top' and 'bottom' of each plot and one guard drill on either side of the area harvested. An area of 14 sq yd per plot was dug i.e. 47% of the original plot area.

About 2 to 3 weeks after lifting, the tubers were graded, by size, into chats (less than $1\frac{1}{4}$ in.), seed ($1\frac{1}{4}$ to $2\frac{1}{4}$ in.) and ware (greater than $2\frac{1}{4}$ in.) by passing the tubers over square-mesh riddles. The weight and number of tubers in each fraction were determined.

Samples of tubers were taken from each plot, after riddling. The tubers, from one plot, were arranged in order of size, approximately, and 15 to 20 tubers selected by removing every n^{th} tuber (where n = number of tubers $\div$ 15 or 20).

In the laboratory the tubers were cut into 'chips' before drying. Dry matter and the concentrations of N, K and Mg in the dry matter were determined.

(i) This experiment, in 1961, at Damside farm, Perthshire, on a sandy loam

soil, was designed originally to give information about the effects of rates and types of fertilizer on the yields and numbers of seed and of ware tubers.

A $2^3 \times 3$, (N x P x K)x T, design was used where:-

N_1 and N_2 were 56 and 112 lb N per acre respectively, as 'Nitro-chalk' and mono-ammonium phosphate.

P_1 and P_2 were 19.5 and 39.0 lb P per acre, respectively, as mono-ammonium phosphate.

K_1 and K_2 were 75 and 150 lb K per acre as T.

T_1, T_2 and T_3 were K_2SO_4, KCl and $KHCO_3$ respectively.

There were 3 replicates, and the 3 x 24 treatment combinations were arranged in 12 randomized blocks, each block consisting of 6 treatment combinations, with the NP, NK, PK, NPT, NKT and PKT interactions partially confounded with block differences (Cochran and Cox, 1960). The layout and treatment randomizations are given in Fig. 6 (a). Treatments were applied on 18 April and the potatoes (var. Arran Pilot) were planted the following day.

Near the end of the growing season, Mg-deficiency symptoms were observed on the foliage. There appeared to be a correlation between these symptoms and treatment, but unfortunately the haulms were destroyed, on 14 August, before leaf samples could be taken. The experiment was harvested on 13 September.

(ii) In late July 1963, at Levenmouth farm (elevation 350'), Kinross, acute Mg-deficiency symptoms appeared in the foliage of potatoes (var. Record) in a field where the soil was a loamy sand. The exchangeable Mg and K contents of this soil, in mg per 100 g, were 2.0 and 4.0 respectively; both values are very low. The total soil-Mg concentration

was 0.3 per cent which is low for cultivated soils in S.E. Scotland.

An experiment on potatoes (var. Record) was laid down in 1964, on another field on this farm, where the soil was similar to the one already described. The design was a 4 x 2 x 2 factorial, where the treatments were the factorial combinations of :-

K_{1-4} - 75, 125, 175 and 225 lb K per acre as a T.

T_1 and T_2 - K_2SO_4 and KCl respectively.

Mg_0 and Mg_1 - 0 and 36 lb Mg per acre as $MgSO_4.H_2O$ (17%Mg).

The treatment combinations were completely randomized within each of the 3 replicates. The layout and randomizations are given in Fig.6(b). A basal dressing of 100 lb N per acre (as 'Nitro-chalk') and 43.5 lb P per acre (as triple-superphosphate) was applied to all plots. All the Mg and P were applied before planting, but to minimize leaching losses the N and the K were applied in 2 dressings:- (a) 60% of the N and of the K were applied with the Mg and P in the bottom of the split-drills and (b) the remainder was applied, between the drills, about one month after planting.

Random leaf (clusters of leaflets) samples were taken from each plot on 10 August, and the experiment was harvested during the last week of September.

IV. RESULTS.

The results from the 5 field experiments are summarised in Tables 1 to 36 in the Appendix. Those from Experiment I(i) are contained in Tables 1 to 20 and the letters a, b and c with these numbers identify the sites at Kingside, Sharplaw and Glendeuglie respectively. Roman numerals have been used for tables of results contained in the text.

All the Figures are presented in Volume II.

The Tables (in the Appendix) and Figures (in Volume II) from Experiment I(i) are in the following sequence - DM yield; per cent N, uptake of N, followed by the corresponding values for P, K and Mg.

Where results have been statistically analysed, the levels of probability, $p \leqslant 0.05$, $p \leqslant 0.01$ and $p \leqslant 0.001$ are represented by *, ** and *** respectively. In a few tables, 'N.S.' is used where results are statistically similar, but 'not statistically significant' is implied, in the majority of tables, by the absence of symbols.

The standard errors (S.E.) presented in Tables 1 to 19 are those of the differences between treatment means, but in the remaining tables the individual treatment S.E. is given.

In the grass experiments (I(i) and I(ii)), T represents either total yield or total uptake in one season and T(n) indicates that T is the sum of the values from n cuts.

EXPERIMENT I(i). NKMg on GRASS.

Sites (a) and (b), 1960.

At each of the 3 cuts from sites (a) and (b) in 1960, the yields of grass and of clover were calculated from the yields of mixed herbage and the

proportion of grass and clover in the samples of mixed herbage taken for analysis. After chemical analysis of the grass and the clover, the uptakes of N, P, K and Mg by each fraction and by the mixed herbage (grass + clover) were calculated. The concentration of each element in mixed herbage was calculated from its uptake by grass + clover and the corresponding yield of mixed herbage.

In the statistical analysis of the results, each site was treated as a separate experiment and no attempt was made to 'combine' sites, as there were differences in the type and magnitude of responses at these two sites.

Since a split-plot design was used, the S.E. for the main N and K effects and NK interaction differ from those for the main effect of Mg and its interaction with N, K and NK.

As site (a) was the more uniform of these sites and coefficients of variation were reasonable for such a 'small' experiment, the results from this site have been used to demonstrate effects which are common to both sites, but differences between sites have been mentioned. The results of all main effects and those interactions which occurred consistently are presented.

Yield (Figs. 7(a) and (b); Tables 1 (a) and (b)).

Although N, with and without K, i.e. N_1K_0 and N_1K_1, increased the yield of grass DM at each cut and T(3), compared with N_0K_0 (except at cut 3 of site (b)), about 80 per cent of the increase in T(3) with N occurred at cut 1. There was therefore little residual fertiliser N for grass at cuts 2 and 3.

The yield of clover DM at cuts 2 and 3 was reduced by the application of N, compared with N_0K_0, and the decrease in T(3) clover yield was about

60 per cent of the corresponding increase in grass yield.

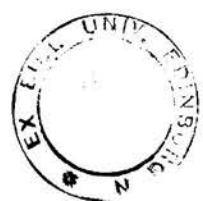
The bulk of the clover contribution came after cut 1; about 90 per cent of the T(3) clover yield, from each N treatment, was taken from cuts 2 and 3. Therefore, when grass and clover are combined, a large increase in mixed herbage (mainly grass) with applied N, at cut 1, is partially offset by decreases at cuts 2 and 3, and although T(3) is increased by N, this increase is only 50 per cent of that at cut 1. While the T(3) yield of mixed herbage, from N_0, is about 80 per cent of that from N_1, the corresponding percentage for grass is only 40. The botanical composition of the yields from the 2 N-treatments is therefore quite different (see Table I).

As there was a striking NK interaction on the botanical composition of the sward at site (b), but not at (a) (Figs. 8(a) and (b)), the 2 sites have to be considered separately when presenting the effects of K on yield.

Table I. Per cent grass in mixed herbage at each cut and T(3), with per cent clover in parenthesis.

Site	Treatment	Cut 1	Cut 2	Cut 3	T(3)
(a)	N_0	93 (7)	40 (60)	27 (73)	49 (51)
	N_1	98 (2)	88 (12)	55 (45)	90 (10)
(b)	N_0K_0	95 (5)	69 (31)	37 (63)	64 (36)
	N_1K_0	98 (2)	92 (8)	44 (56)	87 (13)
	N_0K_1	90 (10)	41 (59)	18 (82)	44 (56)
	N_1K_1	98 (2)	90 (10)	38 (62)	85 (15)

Although K, at cut 3 from site (a), significantly increased the yield of grass by 0.6 cwt per acre, the effects of K on grass and on clover, at this site, were small and inconsistent. At site (b), however, there was a K-alone effect which, although small at cut 1, and significant in the clover fraction



at cut 2 only, was present at all cuts of both fractions. A slight reduction in grass yield at cuts 2 and 3, and a 50 per cent increase in T(3) clover yield resulted from the application of K, compared with N_0K_0. (The yield of clover at each cut was increased by K, in the absence of N.)

The botanical composition of the yields from the N and K treatments at site (b) is presented in Table I.

Since the depressing effect of K-alone on grass yield at site (b) was much smaller than its beneficial effect on clover, the effect of this treatment on the mixed herbage was similar to that on clover. This resulted in the T(3) yields of mixed herbage from N_1K_0, N_0K_1 and N_1K_1 being similar and greater than that from N_0K_0.

Although Mg significantly increased (***) the yield of grass DM at cut 3 of site (a) (Fig. 7(a); Table 1 (a)) the yields at the other two cuts and T(3) were decreased; these effects were small. At site (b) (Fig. 7(b); Table 1 (b)) however, Mg increased the yield of grass DM at each cut and T(3) (* at cut 2 and T(3)). The yield of grass DM at T(3) from Mg was 11 per cent greater than the corresponding yield at Mg_0.

At site (a), Mg increased clover yields at all cuts (but not significantly) and the resulting T(3) increase was 7 per cent of the corresponding yield at Mg_0. Although there was a significant increase (*) in clover yield at cut 1 from site (b), the yields at the remaining cuts and T(3) were decreased.

Over one season the beneficial effect of Mg, at site (a) or (b), on one fraction has been partially offset by an opposite, smaller effect on the other, resulting in a small net positive effect on the mixed herbage. The increases in the T(3) yield of mixed herbage, from Mg, sites (a) and (b) were respectively 1 and 6 per cent of the Mg_0-yields.

Per cent N in DM (Figs. 9 (a) and (b); Tables 2 (a) and (b)).

As there was insufficient clover in the samples from cut 1 to determine N in addition to K and Mg, N concentrations in clover DM at cut 1 are not available. At cuts 2 and 3, the N concentration in clover DM was approximately twice that of the corresponding concentration in grass.

Fertiliser-N increased the N concentration in grass at cut 1 and clover at cut 2 at both sites (also cut 3 from site (b)) but reduced the concentration in grass at cut 3.

Since there was insufficient clover in the mixed herbage samples from cut 1, the N concentration in the mixed herbage was presumed to be similar to that in the grass fraction for the purpose of calculating uptake. The N concentration in mixed herbage was reduced by N at cut 2 from both sites (also at cut 3 of site (a)).

K had no effect at site (a), but at site (b) K, without N, significantly increased (*) the concentration in the mixed herbage at cut 2 (Table 2 (b)).

Mg had little effect on the concentration of N in clover or in grass (except for a significant increase (*) in cut 1 at site (b)).

Uptake of N (Figs. 10(a) and (b); Tables 3 (a) and (b)).

The uptake of N was governed by the effects of N and of K on yield and on botanical composition, and also by the differences between the N concentrations in grass and in clover. The 'apparent' recovery by grass of fertiliser N, at cut 1, where grass was dominant, was about 70 per cent of the amount added, but at site (a) the 'apparent' recovery, by the T(3) mixed herbage, was only 14 per cent, and the value at site (b) was even less.

Because of the beneficial effect of K on clover vigour at site (b), the

uptake of N by the mixed herbage was in the following order - $N_0K_1 > N_1K_1$, $N_1K_0 > N_0K_0$ (Fig. 11 (b)) and the difference in uptake between K-alone and no fertiliser was 35 lb N per acre.

Per cent P in DM (Figs 12 (a) and (b); Tables 4 (a) and (b)).

At cuts 2 and 3, P concentration in clover was about two-thirds of the corresponding concentration in grass.

Of the 3 nutrients applied, N had the greatest effect on P concentration. Mg had little effect at site (a), but at (b) it increased (*) the concentration in grass at cut 1 and at cut 2 decreased (*) the concentration in the same fraction.

Uptake of P (Figs. 13 (a) and (b); Tables 5 (a) and (b)).

Since applied N and K had much greater effects on yield than on the P concentration in herbage, the uptake of P followed the yield pattern.

Per cent K in DM (Figs. 14 (a) and (b); Tables 6 (a) and (b)).

The pattern formed by plotting K concentration against time (cuts 1, 2 and 3), for treatment N_1K_0, was V-shaped for grass but more L-shaped for clover. The ratio of grass-K to clover-K, at cut 1, was different at the 2 sites (at (a) grass < clover and at (b) grass > clover). At cut 2, grass contained slightly more K than clover but at the third cut, grass contained about 3 times as much K as clover.

At cut 1, there was an NK interaction effect on the concentration of K in grass and mixed herbage (significant (*) on grass at site (a)). A substantial increase in concentration occurred when N and K were combined, compared with either nutrient applied alone. N depressed the concentration of K in grass, clover and mixed herbage at cuts 2 and 3.

The concentration of K in grass, clover and mixed herbage was increased at all cuts, by the application of K. These increases in K concentration, expressed as a percentage of the concentration with K_0, are presented in Table II.

Table II. Percentage increase in K concentration, from the application of K, at sites (a) and (b). (Mean of all N and Mg treatments.)

	Cut 1		Cut 2		Cut 3	
Fraction	(a)	(b)	(a)	(b)	(a)	(b)
Grass	31	35	15	20	12	25
Clover	48	69	64	41	66	36
Mixed Herbage	32	36	33	22	34	12

The increase in the K concentration of clover, with applied K, was greater than the increase in the corresponding grass fraction.

Except for an increase (*) in the K concentration of clover at cut 1 from site (b), the effects of Mg on the K concentration were small.

Uptake of K (Figs. 15 (a) and (b); Tables 7 (a) and (b)).

Since the effects of K on yield and on K concentration were complementary, the uptake patterns, for the 2 sites, were similar to the corresponding ones for yield.

The effects of the N and K treatments on the uptakes of K at cuts 1, 2 and 3 and the T(3) uptake, by grass, clover and mixed herbage are presented in Figs. 16 (a) and (b).

The percentage 'apparent' recoveries of fertiliser K at sites (a) and (b), with K-alone (N_0K_1-N_0K_0), were 30 and 32 respectively and, for K with N (N_1K_1-N_1K_0), 46 and 40 respectively.

Per cent Mg in DM (Figs. 17 (a) and (b); Tables 8 (a) and (b)).

The Mg concentration in clover, at all cuts, was considerably greater

than that in grass, which increased linearly from cut 1 to cut 3. There is a suggestion that clover Mg was at a maximum at cut 2.

At cut 1, N increased the Mg concentration in grass and mixed herbage but decreased clover-Mg. The effect of N on grass Mg at cuts 2 and 3 was much smaller than at 1, but clover Mg was increased by applied N at both these cuts. The concentration of Mg in mixed herbage was decreased by N at cuts 2 and 3 of site (a) and at cut 2 of site (b).

The application of K reduced the concentration of Mg in grass and clover at all cuts, except for cut 3 of grass at site (b).

Table III presents the effects of K on the concentration of Mg in grass and in clover; where the decreases are expressed as percentages of the values at K_0.

Table III. Percentage decrease in Mg concentration, from the application of K, at sites (a) and (b). (Mean of all N and Mg treatments.)

	Cut 1		Cut 2		Cut 3	
Fraction	(a)	(b)	(a)	(b)	(a)	(b)
Grass	4	8	5	14	9	(-5)
Clover	14	4	27	15	14	19

At site (a), where K-alone had no effect on botanical composition and yield, its effect on the concentration of Mg in mixed herbage was intermediate between its effects on the Mg concentration of the individual fractions. The percentage reductions in the Mg concentration of mixed herbage at cuts 1, 2 and 3 of site (a) were 8, 22 and 14 respectively.

Because of its beneficial effect on clover vigour at site (b), however, K-alone, compared with N_0K_0 increased the yield of clover and the uptake of Mg by clover and mixed herbage at all cuts. The concentration of Mg in

mixed herbage was increased by K-alone at cuts 1 and 2, as a result of the increased uptake, but decreased at cut 3 because the beneficial effect of this treatment on the yield of mixed herbage at this cut was greater than its effect on Mg uptake.

The effect of K, in the absence of N, on the uptake and concentration of Mg in grass, clover and mixed herbage, at sites (a) and (b), is presented in Table IV.

Table IV. Percentage Mg and the amount removed (lb per acre) in grass, clover and mixed herbage by the treatments N_0K_0 and N_0K_1, at sites (a) and (b).

		GRASS		CLOVER		MIXED HERBAGE	
		N_0K_0	N_0K_1	N_0K_0	N_0K_1	N_0K_0	N_0K_1
Site (a)							
Cut 1	Per cent	0.12	0.12	0.48	0.42	0.15	0.14
	Uptake	1.1	1.3	0.4	0.3	1.5	1.6
Cut 2	Per cent	0.16	0.15	0.49	0.38	0.37	0.28
	Uptake	1.4	1.4	7.1	4.7	8.5	6.1
Cut 3	Per cent	0.23	0.21	0.46	0.41	0.40	0.35
	Uptake	0.7	0.9	4.2	4.0	4.9	4.9
Site (b)							
Cut 1	Per cent	0.09	0.08	0.50	0.49	0.11	0.12
	Uptake	1.2	1.1	0.4	0.9	1.6	2.0
Cut 2	Per cent	0.11	0.09	0.52	0.41	0.23	0.28
	Uptake	1.6	0.9	3.3	5.8	4.9	6.7
Cut 3	Per cent	0.15	0.17	0.43	0.31	0.33	0.28
	Uptake	1.0	0.7	5.1	6.3	6.1	7.0

Since K, in the presence of N, had little effect on clover vigour at either site, when compared with N_1K_0, the effect of this treatment on the Mg concentration in grass, clover and mixed herbage was similar to the effect of K-alone at site (a) viz. that the Mg concentration in these fractions was decreased by the application of K.

The application of Mg increased its concentration in grass, clover and mixed herbage, at all cuts, and the magnitude of these increases, expressed as a percentage of the value at Mg_0, is presented in Table V.

Table V. Percentage increase in Mg concentration, resulting from the application of Mg, at sites (a) and (b).

	Cut 1		Cut 2		Cut 3	
	(a)	(b)	(a)	(b)	(a)	(b)
Grass	20	23	18	14	13	13
Clover	26	50	17	34	16	42
Mixed Herbage	23	34	22	17	13	32

Uptake of Mg (Figs. 18 (a) and (b); Tables 9 (a) and (b)).

Mg uptake was governed by the combined effects of fertilisers on yield, botanical composition and Mg concentration. As a result, N decreased the T(3) uptake by mixed herbage at both sites, K decreased this uptake at site (a) and, at (b), the largest uptake was from K-alone. At site (a), however, most Mg was removed by N_0K_0 (Figs. 19 (a) and (b)).

The amount of Mg removed by grass relative to that removed by mixed herbage, at each cut and T(3), are given in Table VI

Table VI. Mg removed by grass, expressed as a percentage of that removed by mixed herbage, at each cut and T(3) (Sites (a) and (b)).

Treatment	Cut 1		Cut 2		Cut 3		T(3)	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
N_0K_0	71	77	17	32	14	16	22	30
N_1K_0	95	94	59	70	32	20	71	64
N_0K_1	80	56	23	14	18	10	28	18
N_1K_1	95	93	73	62	35	17	77	61

The application of Mg increased the amount of Mg removed by grass, clover and mixed herbage at all cuts, and the resulting increase in T(3) Mg uptake by

mixed herbage at sites (a) and (b) was 2.5 and 3.7 lb Mg per acre respectively. This represents an 'apparent' recovery of only 3 per cent.

Mixed herbage from sites (a), (b) and (c), 1960 to 1965.

Again, the results from each experiment have been analysed separately and no attempt has been made to combine sites. As no yield measurements were made in 1965, yield and uptake data are presented for 5 years and chemical composition for 6. The results of all main effects and those interactions which occurred consistently are presented.

Yield (Figs. 20 (a) to (c); Tables 10 (a) to (c)).

When N was applied in the spring only (1960-1962 and 1964 at sites (a) and (b) and each year at site (c)), the general pattern of yield response to N was an increase at cut 1, followed by decreases at cuts 2 and 3 and (except for sites (a) and (b) in 1961) a net increase in T(2) or T(3) yield. The magnitude of the response to N appeared to fall after 1960.

In 1963, when a total of 120 lb N per acre was applied during the season, at sites (a) and (b), (60, 30 and 30 lb N per acre applied before cuts 1, 2 and 3 respectively) similar increases in yield occurred at each cut from the application of each of the above rates of N.

At site (a) in 1960, the T(3) yield increase from applied K was small, but this positive yield response to K increased in magnitude in 1961 and 1962 and continued in 1963 and 1964. This effect, which occurred both with and without N (Figs. 21 (a) to (c)), was already present in 1960 at the other 2 sites, but increased in magnitude, with time, in a similar manner to site (a). The beneficial effect of K-alone on yield, at site (b), persisted until 1962.

The effect of Mg on T(2) or T(3) yield at site (a) was generally negative but was mainly positive at the other 2 sites. Nevertheless these effects were small: the largest increase being 6 per cent of the Mg_0-yield (1960, at site (b)) and the largest depression was of the same magnitude (1963, at site (a)), neither of which was statistically significant. The only statistically significant increase in T(3) yield from applied Mg (** at site (c), 1962) was only 5 per cent of the Mg_0-yield.

Per cent N in DM (Figs. 22 (a) to (c); Tables 11 (a) to (c)).

From 1960 onwards there was a gradual decline in the N concentration at cut 3 of the K and Mg treatments; these are mentioned because they had much less effect on N concentration than fertiliser N.

Uptake of N (Figs. 23 (a) to (c); Tables 12 (a) to (c)).

When N was applied in the spring only, the general pattern of annual uptake of N was similar to that already described for 1960 (see p. 50).

The value of K-alone, compared with N_0K_0, as a 'source' of clover N, existed in 1960 at sites (b) and (c) where it continued until 1963 and 1964 respectively. K-alone began to take effect at site (a) in 1961 (Figs. 24 (a) to (c)) and the effect continued until 1964.

Per cent P in DM (Figs 25 (a) to (c); Tables 13 (a) to (c)).

The biggest changes in P concentration by fertiliser treatments occurred at sites (b) and (c) and were brought about by N and by K. The N effects were irregular, but K depressed P concentration at each site. There was a suggestion at site (a), from 1963 onwards, and at site (c) from the beginning of the experiment (significant (*) at cuts 1 and 2, 1964), that Mg had increased the concentration of P in DM.

Uptake of P (Figs. 26 (a) to (c); Tables 14 (a) to (c)).

The largest annual uptake of P, at sites (a) and (b), was in 1963, when a total of 120 lb N per acre was applied; the application of N caused 21 and 26 lb P per acre to be removed, in that year, from sites (a) and (b) respectively. The largest annual uptake of P, at site (c), was in 1961.

The effects of fertilisers on P uptake were similar to their effects on yield.

Per cent K in DM (Figs. 27 (a) to (c); Tables 15 (a) to (c)).

When 3 cuts were taken in any one year, the patterns of K-concentration with time, within that year were V-shaped (except sites (a) and (b), 1963); the concentrations at cuts 1 and 3 being higher than those at cut 2. The depressing effect of applied N on the concentration of K in mixed herbage was present at each cut, each year (except cut 1 of sites (a) and (b), 1960), and the magnitude of this effect appeared to increase annually.

Applied K increased K-concentration at each cut, each year, and the difference between the concentrations produced by K_0 and K_1 increased in magnitude from 1960 onwards, largely because the 'average' annual concentration with K_0 fell from 1960 to 1962 and thereafter remained steady, while the 'average' concentration with K_1 remained fairly steady throughout. In many instances the increase in concentration with K were greater than the absolute value at K_0.

These N, K and between-years effects existed at all sites. The presentation in Figs. 27 (a), (b) and (c) demonstrates these effects clearly, but the NK interaction effects which existed within- and between-years are illustrated better in Figs. 28 (a), (b) and (c). When N and K were applied

in the spring only, the decrease in K concentration from cut 1 to cut 2 was greater with N_1K_1 than N_0K_1. The gap in K concentration between N_1K_0 and N_0K_1 increased with time, and this effect persisted in 1965 when no fertilisers were applied.

At site (a), the effects of Mg on K-concentrations were small and generally negative (Fig. 27 (a)), but at (b) and (c) (Figs. 27 (b) and (c)) the effects were positive and occasionally statistically significant (** at (b), 1962 cut 3 and 1963 cut 2; ** at (c), 1961 cut 1).

Uptake of K (Figs. 29 (a) to (c); Tables 16 (a) to (c)).

Applied K had a very much greater effect on K uptake than on yield. For example, at site (a) in 1961, the yield increase and the corresponding increase in uptake of K (both expressed as a percentage of the value at K_0) were 9 and 130 per cent respectively.

The NK interaction effects, with time, are illustrated in Figs. 30 (a) to (c). From 1961 onwards, the uptake of K with N_1K_0 was seldom greater than the uptake with N_0K_0, particularly at sites (b) and (c).

The percentage annual 'apparent' recovery of fertiliser K (assuming no residual K from previous applications) from the N_0K_1 and N_1K_1 treatments, compared with the N_0K_0 and N_1K_0 treatments respectively, are presented in Table VII.

Table VII. Per cent recovery of fertiliser K from N_0K_1 and N_1K_1, at sites (a), (b) and (c).

Year	N_0K_1 (a)	N_0K_1 (b)	N_0K_1 (c)	N_0K_1 (a)	N_0K_1 (b)	N_0K_1 (c)
1960	30	32	35	46	40	42
1961	68	49	79	70	57	92
1962	64	61	68	66	66	77
1963	57	45	69	94	76	73
1964	100	65	58	96	71	53

The effects of K, over 5 years (1960 - 1964), on the total K uptake and recovery, and on the total yield of dry matter, are given in Table VIII.

Table VIII. Total K uptake (lb per acre) and yield of dry matter (cwt per acre) over 5 years (1960 to 1964), from the NK treatments, at sites (a), (b) and (c).

Treatment	K uptake (lb per acre) (a)	(b)	(c)	Yield of dry matter (cwt per acre (a)	(b)	(c)
N_0K_0	245	285	238	195	207	161
N_1K_0	285	289	224	233	263	208
N_0K_1	554	533	547	229	250	213
N_1K_1	657	601	561	265	296	252
N_0K_1-N_0K_0	309	248	309	34	43	52
Per cent recovery	62	50	62	-	-	-
N_1K_1-N_1K_0	372	312	337	32	33	44
Per cent recovery	74	62	67	-	-	-

Per cent Mg in DM (Figs. 31 (a) to (c); Tables 17 (a) to (c)).

At sites (a) and (b) in 1960 and 1961, there was an annual linear increase in Mg concentration from cuts 1 to 3 but a quadratic effect, at these sites, in 1962 and 1963. The concentration at cut 3 in these latter years was not

nearly so high as in the former. At site (c), this effect of season was linear throughout the experiment.

The effect of N on the Mg concentration was not consistent at sites (a) and (b), but at (c) was generally positive. At (a) and (b), N increased Mg concentration at cut 1 in 1960, 1963 and 1964, and decreased it at cut 1 from site (b), in 1961 and 1962; the effects at (a) in these years were negative and small.

The greatest effect of N, at (a) and (b), occurred at cut 2 (from 1960 to 1963 at site (a), and 1960 and 1961 at site (b)) when N decreased Mg concentrations, but at cut 3, these differences had been reduced considerably.

With the exception of cuts 1 and 2 in 1960 and cut 1 in 1961, all at site (b), applied K reduced Mg concentrations at each cut. These reductions are presented in Table IX, expressed as a percentage of the corresponding values at K_0.

Table IX. Percentage decrease in Mg concentration from the application of K, at sites (a), (b) and (c).

	Cut 1			Cut 2			Cut 3		
Year	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
1960	8	(-2)	12	22	(-9)	11	14	7	6
1961	16	(-6)	16	18	3	18	13	4	17
1962	12	6	16	13	11	24	15	9	25
1963	22	18	23	15	12	15	21	13	n.c.
1964	12	16	22	17	13	15	n.c.	n.c.	23
1965	4	12	7	11	2	17	n.c.	n.c.	n.c.

n.c. = no cut.

Applied Mg consistently increased Mg concentration and these increases are presented in Table X as percentages of the corresponding concentrations with Mg_0.

Table X. Percentage increase in Mg concentration from the application of Mg, at sites (a), (b) and (c).

	Cut 1			Cut 2			Cut 3		
Year	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
1960	23	34	24	22	17	15	13	32	18
1961	36	47	27	21	55	33	22	39	26
1962	24	42	28	21	45	28	21	37	35
1963	24	32	35	21	24	26	20	21	n.c.
1964	12	16	30	13	19	30	n.c.	n.c.	20
1965	14	10	21	9	15	38	n.c.	n.c.	n.c.

n.c. = no cut.

The amount of increase in Mg concentration resulting from Mg_1, relative to Mg_0, was governed more by the annual addition of $MgSO_4$ than by the latter's residual effects since the increases in 1963 were almost the same as those at the beginning of the experiment. The increases in Mg concentration at sites (a) and (b) in these years when Mg was not applied (1964 and 1965) were approximately half of what they had been previously.

Uptake of Mg (Figs. 32 (a) to (c); Tables (a) to (c)).

While the effects of N and K on Mg uptake, individually and together, varied with site and season, those of Mg were consistently positive.

In the years 1960 to 1962, N decreased the T(3) uptake of Mg at sites (a) and (b), but increased it in the remaining two years. The T(3) uptake of Mg at site (c) was increased by N, each year.

The main-K effect does not adequately present the effect of K-alone, which varied with time and with site (Figs. 33 (a) to (c)). At site (a), in the years 1960, 1961 and 1962, K-alone removed more Mg than either of the N treatments, which removed less Mg than the control (N_0K_0) in these years

but more than the control in 1963 and 1964. In 1960, 1961 and 1962, K-alone removed more Mg than the other NK treatments at site (b), and at site (c), K-alone was intermediate between the two N treatments which were consistently higher than the control.

The annual increase in Mg uptake, expressed as percentage of the amount at Mg_0, resulting from the application of Mg, is presented in Table XI.

Table XI. Percentage annual increase in Mg uptake resulting from the application of Mg, at sites (a), (b) and (c).

Site	1960	1961	1962	1963	1964
(a)	22	20	17	16	11
(b)	33	47	45	29	11
(c)	23	30	36	24	27

The total uptake of Mg by mixed herbage in 5 years (1960 to 1964) from Mg_0 and Mg_1, and the percentage recovery of the Mg added in this time (360 lb Mg per acre) are presented in Table XII.

Table XII. Total Mg uptake (lb per acre) and percentage recovery, in 5 years, from sites (a), (b) and (c).

	(a)	(b)	(c)
Mg_0	54	51	40
Mg_1	64	69	52
Mg_1-Mg_0	10	18	12
Percentage recovery	2.8	5.0	3.3

Soil Data (Tables 19 (a), (b) and (c)).

Although the pH values were not statistically analysed there was a suggestion that the continued application of N, as $(NH_4)_2SO_4$, compared with N_0, had decreased the pH at each of the 3 sites, by an average of 0.2 pH units.

There was a 10 per cent decrease in the exchangeable Ca concentration at sites (a) and (c) with the application of N, and a decrease in Ca occurred

with the application of K and of Mg (**) at site (c) only.

At all 3 sites, there was a suggestion of an NK interaction effect on the K status. The values with K-alone were higher than those with N and K together. While N_0K_0 and N_1K_0 produced identical exchangeable K concentrations at sites (a) and (b), N_1K_0 produced a lower K status than N_0K_0 at site (c).

Although N and K reduced the exchangeable Mg concentration at all 3 sites, their effects were small compared with the increase in concentration which occurred with the continued use of $MgSO_4$. The increases in exchangeable Mg at sites (a), (b) and (c) were 9.3, 9.4 and 16.0 mg per 100 g soil respectively. These increases are equivalent to 186, 188 and 320 lb per acre respectively (based on 2 x 10^6 lb soil per acre) or 52, 52 and 90 per cent of the amount added over the duration of the experiment.

Botanical composition of swards.

A quantitative estimate of the clover contents of the swards was made only in 1960. However, red clover was observed to be at its peak in 1960 and 1961 but had almost completely disappeared by 1962; white clover remaining on some plots till the end of the experiment. The results in Table 20 (a) to (c) indicate that, under the system of management already described, fertilisers have altered the botanical composition of the swards.

K, with and without N, reduced the proportion of perennial ryegrass in the sward at (b) which had a greater proportion than the other 2 sites. The application of N and of K, individually and together, increased the proportion of cocksfoot at all 3 sites.

The application of N almost completely killed out white clover at sites (a) and (b), but at (c) where K-alone produced a sward with twice as much

white clover as N_0K_0, N-alone considerably reduced the proportion but N and K applied together produced as much clover as N_0K_0. There was no benefit from K-alone at (a) but at (b) it produced a 50 per cent increase in white clover.

EXPERIMENT I (ii). Mg COMPOUNDS on GRASS (1964 to 1967).

The compounds for treatments B, C, D (all calcined magnesite), G (magnesium ammonium phosphate) and H (magnesian limestone) were applied in 1964 only, at the beginning of the experiment, but treatments E and F (both Epsom salt) were varied annually. The annual amounts of Mg supplied in E and F, and the cumulative totals (in parenthesis), were as follows:-

	1964	1965	1966	1967	
E	20 (20)	20 (40)	60 (100)	60 (160)	lb Mg per acre
F	60 (60)	- (60)	120 (180)	120 (300)	lb Mg " "

Yield (Fig. 34; Table 21 (a)).

The effects of Mg on yield were generally small and seldom significant, particularly when all 8 treatments were included in the one statistical analysis. At cut 1 in 1964, there were no statistically significant effects in the original statistical analysis (Table 21 (a)), but when the results from A, B, C and D were analysed by themselves there was a significant quadratic effect (**), in which treatments B and C were greater than A and D respectively. The mean yield of dry matter (cwt per acre) from these treatments and the standard error of each treatment mean are given in Table XIII.

Table XIII. Yield of dry matter (cwt per acre) at cut 1, in 1964, from treatments A (control), B, C and D (calcined magnesite).

A	B	C	D	S.E.±
38.5	43.7	43.3	38.8	1.18

The average yield increase from B and C was 13 per cent, when compared with the no-Mg treatment (A).

These 4 treatments had no effect on yield at cuts 2 and 3; therefore the non-significant quadratic effect which appeared at T(3) had its origins at cut 1. Similar quadratic patterns existed in the total yields in 1965, 1966 and 1967 but, in these years, the differences were very much smaller than in 1964 and were not statistically significant.

Treatment G appeared to be better than A at cuts 1 and 2 and T(3), in 1964.

Chemical composition of herbage.

Variations, with time, in the concentrations of N, P, K, Ca and Mg in herbage DM, from the no-Mg control treatment (A), are given in Fig. 35. (The complete chemical analysis data are given in the following Tables:- N - 22(a); P - 23(a); K - 24(a); Ca - 25(a); Mg - 26(a).) The concentration of K was greater than N at cuts 1, 2 and 3, each year (except cut 3 in 1964), but in 1964, 1965 and 1966, K was less than N at the final cut. The annual pattern of concentrations of these two elements in herbage, in this experiment, was either V- or U-shaped. The concentrations of Ca appeared to follow similar time-patterns to those of Mg, which increased from cut 1 to cut 3 or 4; when the Mg concentration dropped from cut 3 to cut 4 in 1965, so did Ca.

The annual uptakes of N, P, K, Ca and Mg in herbage from treatment A are presented as histograms in Fig. 36. The amounts of N, P and K added annually in fertilisers and the corresponding annual amounts removed in herbage from treatment A are presented in Table XIV.

Table XIV. Amounts of N, P and K added in fertiliser (lb per acre) and amounts removed by herbage (lb per acre) from treatment A.

		1964	1965	1966	1967
N	Added	71	73	87	87
	Removed	117	156	156	127
P	Added	15	32	38	38
	Removed	19	25	24	21
K	Added	29	93	112	112
	Removed	157	218	219	166

An N-deficit is not serious since the extra amounts required can normally be supplied by the soil without harm, but it is essential to retain a reasonable balance for P and for K. The P balances are fairly satisfactory but the large K deficits could be serious for future crops. The annual amount of K removed did not appear to be related to the corresponding amount applied; the amounts of K removed at cut 1 each year were remarkably similar and ranged from 119 to 129 lb K per acre when the applied was 29 and 112 lb per acre respectively.

Per cent Ca in DM (Table 25 (a)).

Treatment H (1.2 tons magnesian limestone per acre), which supplied 580 lb Ca per acre in addition to 300 lb Mg, had little effect on the Ca concentration in herbage.

Although the effects of the calcined magnesite treatments (B, C and D) were significant only at cut 1 in 1964 and cut 3 in 1967, the general trend, each year, was for these treatments to decrease the concentration of Ca (Fig. 37). There is a suggestion that the higher rates of Epsom salt (treatments E and F in 1966 and 1967) have also done this.

Per cent Mg in DM (Table 26 (a)).

The application of Mg increased the concentration of Mg in herbage. The magnitude of the increases in concentration from the 7 Mg treatments is given in Table XV, where each increase is expressed as a percentage of the corresponding concentration with no Mg (Treatment A).

Table XV. Percentage increase in herbage-Mg concentration resulting from the application of Mg.

Year	Cut	B	C	D	E	F	G	H
1964	1	19	26	44	17	10	17	12
	2	-	4	15	2	-	-	-
	3	10	43	49	5	14	4	25
1965	1	17	23	29	23	7	15	28
	2	8	19	42	19	22	27	23
	3	10	20	35	13	13	17	18
	4	12	27	41	11	16	21	34
1966	1	13	20	24	19	32	15	20
	2	10	28	42	18	40	13	16
	3	9	9	32	14	27	13	25
	4	4	13	34	18	23	11	19
1967	1	9	21	31	47	57	24	28
	2	6	8	19	26	33	8	33
	3	5	14	28	30	34	11	16
Average		9.4	19.6	33.2	-	-	14.0	21.2

Fig. 38 shows that calcined magnesite (B, C and D) was as effective in increasing the Mg concentration in herbage in the fourth year (1967) of the experiment as it was in its year of application. The slopes of the graphs in Fig. 38 are similar, in any one year and, allowing for variations within-years, vertical distances between corresponding lines, in different years,

are practically the same.

Fig. 39 presents the effects of Epsom salt and of magnesium ammonium phosphate on herbage Mg. While the increases from magnesium ammonium phosphate (G) were steady throughout the experiment and, on average, better than those from the equivalent amount of Mg as calcined magnesite (B, C and D), Epsom salt (E and F) was more effective in increasing herbage Mg concentration after 1965, when applied annually and at higher rates than in 1964. In 1966 and 1967, when Epsom salt was applied annually at rates equivalent to 60 and 120 lb Mg per acre, the increases in herbage Mg concentration were of the order of 20 to 40 per cent, but the higher rate was less than twice as effective as the lower.

Fig. 40 presents the effects of increasing amounts of Mg, as calcined magnesite, on herbage Mg concentration, and compares its highest rate (300 lb Mg per acre) with the equivalent amount of Mg supplied by magnesian limestone. The first cut was taken at approximately the same time each year (24 to 27 May) but the Mg concentration in the herbage from treatment A, at this cut, increased from 1964 to 1967, as follows - 0.10, 0.12, 0.13 and 0.15 per cent Mg, in successive years.

The average increases in Mg concentration from 60 and 120 lb Mg per acre as calcined magnesite (B and C) were 9.4 and 19.6 per cent respectively i.e. there was a linear relationship, with these levels of Mg, between application-rate and increase in Mg concentration. However, the curves become quadratic beyond 120 lb Mg. The highest rate, 300 lb Mg per acre is equivalent to 5 times the lowest rate (i.e. D = 5 x B), but D increased the Mg concentration of herbage only three times as much as B. The magnesian limestone treatment (H) was only about half as effective as its calcined magnesite equivalent (D)

in increasing Mg concentration in the year of application but with time more Mg from the magnesian limestone became 'available' until, in 1967, its efficiency in increasing the Mg concentration was about 70 per cent that of treatment D.

Uptake of Mg (Fig. 41; Table 26 (b)).

The application of Mg consistently increased the amount removed by the herbage. The annual and total per cent recoveries of Mg from the 7 Mg treatments are given in Table XVI. (The cumulative total of amount of Mg applied has been used for treatments E and F.)

Table XVI. Percentage recovery of applied Mg.

Year	B	C	D	E	F	G	H
1964	2.8	2.4	1.0	6.3	1.6	2.2	0.2
1965	1.2	1.9	0.7	3.4	2.0	2.8	0.7
1966	3.0	2.7	1.2	2.5	2.3	3.1	0.8
1967	1.9	1.9	1.0	2.8	1.9	2.8	0.9
Total	8.9	8.9	4.0	6.0	4.0	11.0	2.7

In terms of percentage recovery, the lower rates of application of calcined magnesite and of Epsom salt were more efficient suppliers of Mg than the higher rates of the same compound.

Soil Data (Table 27 (a)).

At each sampling date, treatments had very little effect on pH, or on exchangeable Ca or K. The effect of time on the decrease in exchangeable bases (Ca, K and Mg) was much greater on K than on either Ca or Mg. (Fig. 42 demonstrates this effect; the results are from the no-Mg treatment - A.) The exchangeable Ca, K and Mg concentration in March 1964 were 214, 14.7 and 8.6 mg per 100 g respectively and the corresponding values in December 1966 were 175, 7.6 and 7.6. These latter values represent decreases, from the

original samples, of 18, 48 and 12 per cent respectively.

Exchangeable Mg.

The application of Mg increased the exchangeable Mg concentrations. Table XVII presents these increases in lb per acre, at each sampling date (based on 2 x 10^6 lb soil per acre).

Table XVII. Increase in exchangeable Mg concentration (lb per acre) resulting from the application of Mg.

Date	B	C	D	E	F	G	H
5. 1. 65	19	66	156	13	35	19	69
30. 3. 65	15	54	133	4	21	-	68
4. 4. 66	45	73	180	31	50	29	149
22.12. 66	52	110	209	89	167	70	177

There is an increase in exchangeable Mg concentration with time, for treatments B, C, D, G and H, which were applied once only, but the rate of increase from magnesian limestone (H) is much greater than from calcined magnesite treatments (Fig. 43). Fig. 44 which compares the effects of the control, Epsom salt and magnesium ammonium phosphate treatments, shows the large increase which occurred in 1966, when higher rates of Epsom salt (E and F) were used, and also that the amount of exchangeable Mg from magnesium ammonium phosphate (G) is increasing with time.

The increases in exchangeable Mg concentration from the calcined magnesite treatments were linear at all sampling dates (Fig. 45 (a)). The amount of exchangeable Mg resulting from the magnesian limestone treatment (H) increased with time (Fig. 45 (b)), and at the last sampling an exchangeable Mg concentration equal to 85 per cent of its calcined magnesite equivalent had been produced.

EXPERIMENT II. NKMg on BARLEY.

Chemical composition of leaves (Table 28 (a)).

Mg decreased the concentrations of N and of K in the July leaf-samples by 6 and 7 per cent respectively, and increased the Mg concentration by 16 per cent. K increased the K-concentration by 6 per cent and decreased that of Mg by 11 per cent.

Chemical composition of straw (Table 31 (a)).

In the straw at harvest, Mg decreased the N and the P concentrations by 10 and 9 per cent respectively, and increased Mg by 13 per cent. K increased the K concentration by 13 per cent but had no effect on Mg.

Chemical composition of grain (Table 29 (a)).

Mg decreased the N in grain by 6 per cent and increased Mg by 3 per cent.

Yield of grain and uptake of nutrients (Table 30 (a)).

N increased the yield of grain and the uptake of Mg by 19 and 17 per cent respectively, and Mg, which had no effect on Mg uptake, reduced the uptake of N by 9 per cent.

EXPERIMENT III. POTATOES.

(i) NPKT (Table 32 (a)).

K_2, compared with K_1, increased the concentrations of K and of Mg in the DM of tubers by 14 and 11 per cent respectively. The total yields of tubers from these two levels of K were not statistically different ($K_2 - K_1 = 0.34$ tons per acre); therefore the uptake of Mg, by tubers, at the two levels of K would be proportional to their respective Mg concentration.

(ii) KTMg.

In order to show more clearly the general patterns of nutrient concentration

in the leaves and tubers, the main effects will be considered first, as if there were no interactions, since the latter in this experiment modify only magnitude without changing sign.

Leaf samples (Table 33 (a)).

The application of K_4, compared with K_1, increased the K concentration in the leaves by 74 per cent, but decreased that of Mg by 30 per cent. Both of these effects were linear over the complete range K_1 to K_4.

KCl, compared with K_2SO_4, and Mg_1, compared with Mg_0, increased the Mg concentration in leaves by 7 and 24 per cent respectively.

The significant interaction effects, KMg(*) and TMg(***) are demonstrated in Fig. 46 (a) and (b) respectively. In the KMg interaction, the pattern of decline of Mg concentration with increasing rate of K, was more regular without Mg than with. The TMg interaction shows that KCl increased the Mg concentration of leaves, relative to K_2SO_4, only when Mg was applied.

Tuber samples (Table 34 (a)).

The application of K_4, compared with K_1, increased the K and the Mg concentration in tubers by 34 and 15 per cent respectively. (Both these effects are linear over the complete range K_1 to K_4.) (The values of the ratio per cent K : per cent Mg, at K_1, for the leaves and the tubers are approximately 3:1 and 14:1 respectively.)

K_2SO_4, compared with KCl, and Mg_1, compared with Mg_0, increased the Mg concentration in tubers by 6 and 7 per cent respectively.

Yield of tubers and uptake of nutrients (Table 35 (a)).

The total yield of tubers (ware, seed and chats) and their uptake of Mg were increased with the application of K_4, compared with K_1, by 25 and 33

per cent respectively. (Both these effects were linear throughout the range K_1 to K_4.)

K_2SO_4, compared with KCl, and Mg_1, compared with Mg_0, both increased the uptake of Mg in tubers by 10 per cent.

The significant KMg(*) interaction-effect on the uptake of Mg by tubers is shown on Fig. 47. The difference between the uptakes of Mg with Mg_1 and Mg_0 is greater at K_4 and K_3 than at the lower rates, and the difference at K_4 is greater than at K_3. These values are given in Table XVIII.

Table XVIII. Increase in Mg uptake (lb per acre), from the application of Mg, at different levels of K.

	Mg_0	Mg_1	$Mg_1 - Mg_0$
K_1	6.5	6.7	0.2
K_2	7.6	7.5	-0.1
K_3	7.3	7.9	0.6
K_4	7.8	9.8	2.0
Average	7.3	8.0	0.7

While the 'apparent' recovery of added Mg at K_4 is 6 per cent, that at K_1 is only 0.6 per cent, with an overall average of 2 per cent.

V. DISCUSSION.

The object of this investigation was to study the effects of fertilisers, containing N, K and Mg, on the quantities of Mg removed in the harvested fractions of grass, clover, mixed herbage, barley and potatoes. Removal, or uptake is the arithmetical product of yield and nutrient concentration. Since these two variables do not always respond to an applied plant-nutrient in the same manner, they will be discussed together under the main headings of 'Effects of N' followed by the effects of K, NK and Mg

EFFECTS of N.

Grass.

The Mg concentration in the grass fraction in 1960 was lowest at the first cut (Fig. 17) and increased with time to a maximum value at cut 3. Todd (1961a) reported similar effects.

The application of $(NH_4)_2SO_4$, supplying 80 lb N per acre, increased the Mg concentration in grass and also the yield of grass DM at cut 1, thus greatly increasing the uptake of Mg. While Mulder (1956) found that NH_4-N, but not NO_3-N, reduced the Mg concentration of oat and wheat plants in acid soils, Rook and Wood (1960) found that NH_4-N consistently increased the Mg concentration of a predominantly cocksfoot sward. Will (1961) and Alston (1966b) suggest that the Mg-NH_4 antagonism reported by Mulder occurs only where soil conditions prevent the rapid nitrification of the NH_4-N and, as a result, that increases in plant-Mg concentration from NH_4-N should really be attributed to NO_3-N. It is therefore reasonable to assume that rapid nitrification of NH_4-N to NO_3-N resulted in the increased Mg concentration in the grass DM at cut 1.

Since the equivalent of approximately 70 per cent of applied N had been

removed by the grass at cut 1 there was little residual fertiliser N to affect yield, Mg concentration or Mg uptake at cuts 2 and 3.

Clover.

The stimulating effect of N on the yield of grass DM early in the season greatly reduced clover yield later (Fig. 7), and since more than 90 per cent of the total clover yield came after the first cut, the reduction in total clover yield from the application of N was considerable. Although Walker et al. (1953) found that $(NH_4)_2SO_4$ depressed clover yield more than 'Nitro-Chalk', when applied at equivalent rates of N, the present work indicates that although the $(NH_4)_2SO_4$ depressed clover vigour in 1960, the proportions of clover in the N and no-N swards, at the end of that season, were similar. The proportion of clover in the mixed herbage from N_0 plots increased rapidly from cut 1 to cuts 2 and 3 (Table I, p.51) but the proportion in the N_1 plots, although small at cuts 1 and 2, rose sharply at cut 3, and, as a result, almost 'caught-up' with N_0.

Since cutting frequently can reduce the depressing effect of N on the proportion of clover in a sward (Barbier, 1964), clover vigour in a grazed sward is unlikely to be affected by a rate of N similar to that used in this experiment.

Wolton (1960) suggested that the concentration of Mg in clover DM was 1.5 times that in grass DM, but in this experiment the factor was much greater; between 4 and 5 at cut 1 and between 2 and 3 at cut 3.

The Mg concentration in clover DM appeared to be at a maximum at cut 2 (Fig. 17). Todd (1961a), with pure clover swards in pots, found a small increase in concentration as the season advanced but Reith (1963) found that season had little effect on clover Mg, from regularly-cut mixed herbage.

The effect of $(NH_4)_2SO_4$ on the concentration of Mg in clover was similar to that reported by Hemingway (1961b), who, in the first year of a 3-year experiment, found that N decreased clover Mg at the first cut but thereafter increased it.

These effects of applied N could be the result of, first, competition from grass stimulated by N, and later in the season an increase in Mg concentration resulting from slower clover growth. At cut 1, applied N, in addition to stimulating grass growth, may also have impaired the growth of clover roots and reduced their ability to remove 'available' Mg, thus depressing the concentration in the plant, relative to that at N_0. On the other hand, clover was the dominant species in the N_0 plots at cuts 2 and 3 when it was growing rapidly. As a result of growth being more rapid than Mg uptake, the Mg concentration would decrease relative to the slower-growing clover in the N_1 plots.

The application of N decreased the uptake of Mg by clover at each cut; the decrease being greatest at cut 2.

Mixed Herbage, 1960.

Uptake of Mg.

Since the decrease in total uptake of Mg by clover, with applied N, was greater than the corresponding increase in uptake by grass, about 20 per cent more Mg was removed by mixed herbage in 1960 from the N_0 than from the N_1 treatments. The net effect of N on Mg uptake at each cut was governed by its effects on yield, botanical composition and Mg concentration.

Per cent Mg.

The percentage Mg in mixed herbage is governed by the proportion of clover relative to grass and not by the absolute quantity of clover present.

Since clover DM contained at least twice as much Mg as that of grass, changes in the botanical composition of mixed herbage (Table I, p.51) brought about by applied N had a much greater effect on the Mg concentration in mixed herbage than the effects of N on the Mg concentration of the individual fractions (Fig. 17 and Table VI, p.58).

Although N_1 at cut 1 significantly increased the Mg concentration in mixed herbage from 0.13 to 0.15 per cent (mean of 2 sites), this increase was much less than that which occurred in grass alone viz. 0.10 to 0.14 per cent. The amount of clover present at the first cut was small, but the 7 per cent present in the N_0 treatments was sufficient to raise the Mg concentration from 0.10 per cent in grass-alone to 0.13 per cent in mixed herbage, whereas the corresponding percentages were 0.14 and 0.15 for the N_1 treatment with only 2 per cent clover.

The linear increase in Mg concentration with time (Fig. 17) followed a similar pattern to the increase with time of the percentage clover in the mixed herbage (Table I, p.51). Differences in Mg concentration resulting from applied N were greatest at cut 2 (Fig. 17) where the greatest differences in clover concentration occurred.

Mixed Herbage, 1960 - 1964.

Yield of DM.

The fact that the effects of N on the yield of mixed herbage at the 3 sites were generally similar to those at (a) and (b) in 1960, would suggest that the initial increase in yield, from applied N, was in the grass fraction and that clover was important in the N_0 plots at cuts 2 and 3. The decreases in yield from applied N at these 2 cuts were smaller at (c) than at the other 2 sites.

In 1963, when N was applied before each cut (at (a) and (b)), the yield increase at each cut would be in the grass fraction.

Per cent Mg.

Since the effects of N on the Mg concentration were generally positive at site (c) but variable at (a) and (b), site (c) will be considered first.

Site (c). At the first cut from this site the Mg concentration in the DM of grass and of clover samples with N_0 was 0.11 and 0.36 per cent respectively; the corresponding values with N_1 were 0.13 and 0.33 per cent. The percentage Mg in grass was similar to that found at (a) and (b) and the clover-Mg concentrations were lower, but the effects of N on the Mg concentration of these fractions were similar to those at (a) and (b) and also statistically significant.

The first cut, at this site, was generally one week and cuts 2 and 3 two or three weeks, earlier than the corresponding cuts at (a) and (b). This system of cutting appears to have permitted better conservation of clover, despite the application of N, at (c) than at the other two sites (see Table 20).

The smaller reductions in DM yield from applied N at cuts 2 and 3 from site (c), relative to the corresponding cuts at the other two sites (Table 10) may therefore have been due to a higher proportion of clover in the N_1 plots at this site. In addition, since only 50 per cent of applied N was recovered at the first cut compared with about 70 per cent at the other sites (Table 12) there would be some residual N at (c) to increase yield and the Mg concentration in grass at cut 2. The presence of residual N and its effect on herbage Mg at cut 2 combined with the greater proportion of clover in the N_1 plots, relative to the corresponding plots at (a) and (b), have caused N to increase the Mg concentration of the mixed herbage at most cuts.

Sites (a) and (b). Although some clover remained in the N plots at the end of 1960 (Table I, p.51) this gradually disappeared until, in 1965, practically no clover remained in these plots (Table 20). Reith and Inkson, et al. (1964) found that 87 lb N per acre per annum as 'Nitro-Chalk' almost completely killed out clover in 3 years.

The effects of N on the Mg concentration in mixed herbage in the years 1961 to 1964 can be explained by reference to the 1960 results. An increase in the Mg concentration in mixed herbage occurred as a result of the application of N, at the first cut in 1960, 1963 and 1964 because the increase in Mg concentration in grass with N_1 (and therefore in mixed herbage, since there is little clover), was greater than the increase in Mg concentration in mixed herbage, in the N_0 plots, caused by the greater clover concentration. However, when the increase in the proportion of clover in the N_0 plots, relative to the N_1, resulted in a higher Mg concentration in mixed herbage (1961 and 1962), applied N decreased Mg concentration at cut 1. Decreases in Mg concentration from applied N occurred at cut 2 mainly because the proportion of clover in the N_0 plots was very much greater than with N_1.

Mg concentration - time patterns.

A linear increase in the Mg concentration with time occurred each year at site (c) and in 1960 and 1961 at the other two sites, because of corresponding increases in the proportion of clover in the mixed herbage.

While red clover was the dominant clover in 1960 and 1961, only a small amount was present from 1962 to the end of the experiment. This change in botanical composition coincided with a change in the Mg concentration - time pattern at sites (a) and (b) (Fig. 31), brought about perhaps by the fact that white clover, which remained, being slightly earlier than red clover,

reaches its peak proportion in herbage at cut 2 and with no further increase at cut 3 produces similar herbage Mg concentrations at these cuts. As a result, Mg concentration - time patterns from 1962 to 1964 at (a) and (b) were more quadratic than linear.

A linear increase in Mg concentration with time occurred each year at site (c), even after the disappearance of red clover, because here the proportion of white clover in the herbage had not reached its maximum at cut 2, as this cut was taken 2 or 3 weeks earlier at this site than at the others. This theory appears to be confirmed by the fact that while, at cut 2, the Mg concentration at site (c) is lower than that from the corresponding cut at the other two sites, at cut 3 the Mg concentrations from all sites are similar.

Uptake of Mg.

Site (c). At this site, the decrease in yield which was induced each year at cuts 2 and 3, by the application of N, was associated with an increase in Mg concentration. The net result of these two effects of N at these two cuts was generally to reduce Mg uptake but only by a small amount. When this small decrease is combined with the larger increase in uptake which was produced by N at the first cut, as a result of an increase in yield and Mg concentration, there is a net positive effect of Mg on the total uptake of Mg in one season.

Sites (a) and (b). At these sites, the net negative effect of applied N on the total uptake of Mg each year from 1960 to 1962 was the result of (i) an increase in yield at cut 1 associated with a relatively small variable effect on Mg concentration producing an increase in Mg uptake, (ii) a decrease in

yield and in Mg concentration at cut 2 combining to decrease uptake and (iii) a decrease in yield at cut 3 associated with a variable effect on Mg concentration resulting in a decrease in uptake. The sum of effects (ii) and (iii) is greater than (i). When N was applied before each cut in (1963), yield, Mg concentration and uptake at each cut were increased.

Soil Data.

At the beginning of the experiment the pH values at (a), (b) and (c) were 6.1, 6.4 and 6.1 respectively and those from the N_0 plots at the end of the experiment were 5.9, 6.1 and 6.6. 'Lime' was not applied to any site during the experiment but unreacted lime may have been responsible for the increase in pH with time at (c). The small decreases which occurred at (a) and (b) follow the expected pattern but these decreases and the increase at (c) include the combined effects of time, sampling error and seasonal variation (Robertson and Simpson, 1954).

The decrease in exchangeable Ca and Mg concentrations and pH which occurred with the continued use of $(NH_4)_2SO_4$, (Table 19) agree with the findings of Chang and Chu (1960).

Botanical Composition.

The application of N increased the proportion of cocksfoot at each site but depressed the proportion of clover at (c) and almost completely killed it out at the other two sites. Reith and Inkson et al. (1964) found that although the proportion of ryegrass was also increased by N, the increase in the proportion of cocksfoot was greater.

Barley

The small increase in Mg concentration in the leaf samples taken in July amd in the straw samples at harvest (6 and 2 per cent respectively), from the

application of $(NH_4)_2SO_4$ (40 lb N per acre), were not statistically significant. However the leaves contained twice as much Mg in the DM as the straw.

Applied N, which had no effect on the Mg concentration in grain, increased Mg uptake by increasing grain yield (increase in yield and uptake was 19 and 17 per cent respectively). Even if 50 per cent of the expected grain yield was lost during the storm which occurred before harvest (see p.45), and if this loss was directly proportional to yield, then only 2.9 and 3.4 lb Mg per acre would have been removed in 35 and 42 cwt per acre grain from the N_0 and N_1 treatments respectively.

Chambers (1953) found that the concentration of Mg in all parts of the wheat plant decreased during growth and that a large proportion of stem and leaf Mg was transferred to the ear. Most of the total Mg requirement of a cereal must, therefore, be taken up during the early stages of growth, and eventually appear in the grain. Alston (1966b) reported that, where nitrification was rapid, $(NH_4)_2SO_4$ had no effect on the Mg concentration in barley grain, although, at 4 earlier stages of growth, it had increased the Mg concentration in barley plants. In another experiment, this worker (1966a) found that while $Ca(NO_3)_2$, compared with no-N, generally increased the Mg concentration in oat plants grown in a Mg-deficient, acid, sandy soil (pH 4.6), $(NH_4)_2SO_4$ decreased the Mg concentration compared with no-N, unless the soil pH was increased with $CaCO_3$, when it behaved in a similar manner to $Ca(NO_3)_2$.

EFFECTS of K

Grass, Clover and Mixed Herbage, 1960

In 1960, N without K, produced the same total yield of grass, clover and mixed herbage as N and K applied together. Reith and Inkson *et al.* (1961), in a series of 3-year grassland experiments, found that yield responses to K

in the first year were generally small, even on soils with low levels of 'available' soil K.

The increase in yield and proportion of clover at site (b), from the application of K-alone, did not occur at (a). Reith and Inkson et al. (1964) reported an increase in the proportion of clover with applied K at five out of their six sites.

Rich and Odland (1947) found that the proportion of legumes in a grass-legume sward could be increased from 30 to 50 per cent by increasing the rate of application of K from 40 to 80 lb per acre. McNaught (1959, 1960) has suggested that this response to K occurs on K-deficient soils, but the exchangeable K concentration of the soil at site (b) although 'low' (5.6 mg per 100 g soil) would not have been classified 'deficient'. The site where Reith and Inkson et al. (1964) did not find an increase in the proportion of clover with applied K had a 'slightly low' available K status, yet a response occurred at the other five sites where the K values ranged from 'low' to 'satisfactory'.

The assessment of nutrient 'availability' by a chemical method is unreliable since different plant species have different capacities for extracting nutrients from soil. For example, Drake and Scarseth (1939) found that timothy and Sudan grass removed amounts of K equivalent to at least twice the exchangeable K concentration, sweet clover took up an amount equivalent to that in the exchangeable form but oats could remove only half.

In this experiment, grass DM from the two sites has similar K concentrations but the concentration of K in clover is much lower at site (b) than at (a) (Fig. 14 and Table 6). This would suggest that clover is a much better indicator of K deficiency than grass. While the increase in the yield of

clover at site (b), brought about by K-alone caused a reduction in the yield of grass (Table 1; Fig. 8(b)) the increase exceeded the decrease, in magnitude.

The application of KCl (100 lb K per acre) decreased the Mg concentration in grass and in clover at both sites. At site (a), the average decreases were 6 and 18 per cent respectively, but at (b) the average decrease in clover Mg was much less than at (a) (Table III, p.56). Although the difference in Mg concentration in the mixed herbage, between the K_0 and K_1 plots, increased from the first to the third cut in 1960 (Fig. 17), time of cutting had little effect when the difference was expressed as a percentage of the Mg concentration with K_0, since this concentration increased with time (Fig. 17 and Table III, p.56). Hemingway (1961a), however, reported that while the average seasonal decrease in grass and clover Mg from the application of 2 cwt per acre KCl, was 7.5 and 4 per cent respectively, the greatest reduction occurred in late-season samples.

Since the effect of K, with and without N, at site (a), was on Mg concentration only, Mg uptake by grass and clover were reduced by the application of K. This application, therefore, also reduced the uptake and concentration of Mg in the mixed herbage. At (b), N_1K_1 compared with N_1K_0, behaved in the same manner as 'main K' at site (a), but K-alone both increased clover yield (and the proportion of clover in the mixed herbage) and decreased the Mg concentration in clover and also in grass. The net result was that K-alone increased the Mg uptake by clover and the total uptake in clover and grass more than the other treatments (Fig. 19b). Mg concentration in the mixed herbage was thus increased at cuts 1 and 2 by the application of K-alone. The decrease in concentration at cut 3 from N_0K_1 compared with N_0K_0 was the result of a proportionately bigger decrease in clover Mg concentration than

increase in yield.

McNaught (1959) postulated that, since clover has a higher Mg content than associated grasses, the application of K to deficient pastures could result in a mixed herbage with a greater proportion of clover but similar Mg concentration. Since in my work applied K, in the absence of N, increased the Mg concentration in mixed herbage from site (b) at 2 out of 3 cuts, the potential of applied K can in fact be greater than that predicted by McNaught.

Even at site (b), where both the yield and the K concentration of herbage were increased by applied K in 1960, the recovery of this nutrient from the K-alone treatment was relatively small (32 lb K per acre or 32 per cent). Since most of the K in herbage, ingested by animals, is returned to grazed-pasture in urine and excreta, the annual K requirement of a grazing sward is less than that of grass cut for conserving. With moderate N rates (40 - 80 lb per acre), the K requirement of a grazed sward will be 40 - 50 lb per acre (or 60 - 80 for soils deficient in K).

Mixed Herbage, 1960 - 1964.

Yield of DM.

The application of K-alone increased clover vigour at site (c) in 1960 and each year until the end of the experiment in 1965. This effect was observed, deduced from its effects on the concentrations of N and Mg in the herbage DM each year, and supported by the botanical composition of the swards in 1965. (Table 20(c)). The exchangeable K concentration of this soil (9.8 mg per 100 g soil) is certainly not within the 'deficient' category; it has, in fact, a slightly higher K status than the soil at site (a) (p.38) where no such effect occurred. Clover must therefore require a large supply

of readily 'available' K within its root zone, but the exchangeable fraction appears to be a poor estimate of the amount of soil K that is readily 'available' to clover.

The yield response to K_1, although very much smaller at site (a) than at the other two sites in 1960, increased with time at each site. This effect was observed by Reith and Inkson et al. (1961) and by Heddle (1967). As reported by Widdowson et al. (1965), these yield increases (expressed as per cent) are very much less than the associated percentage increase in K uptake required to produce them (Table VIII, p.63). Methods of preventing this 'luxury' uptake of K, which is wasteful and could be harmful to livestock, will be discussed in the 'General Discussion' section.

Per cent K.

While the concentration of K in the herbage from the K_0 treatments fell to a minimum and perhaps critical level in 1962 and remained near this level for the remainder of the experiment, that from the K_1 treatments remained, on average, fairly steady throughout the experiment. As a result of the gap in K concentration from these treatments widening from 1960 to 1962 (Fig.27) and also the yield response to K increasing from 1960 to 1964, the 'apparent' recovery of applied K increased with time (Table VII, p.63).

Uptake of K.

The amounts of K removed from each site, in 5 years, by corresponding treatments, were remarkably similar (Table VIII, p.63) and the average amount of K removed per site per annum (calculated from Table VIII) was as follows:-

N_0K_0	N_1K_0	N_0K_1	N_1K_1	
51	53	109	121	lb K per acre

Although there is an average annual deficit of K in the N_0K_0, N_1K_0 and

N_1K_1 treatments, the N_0K_1 treatment has produced an almost balanced output-input. If we consider that the 'small' annual deficits of 'available' K in the N_0K_0, N_1K_0 and N_1K_1 treatments (equivalent to 2.6, 2.7 and 1.1 mg exchangeable K per 100 g soil respectively) are 'made good' by the breakdown of less readily-available forms of K, the exchangeable soil K from the K_0 and K_1 treatments at the end of the experiment should be similar to each other but should be different from those at the beginning of the experiment. This did in fact occur.

The exchangeable K concentration at sites (a), (b) and (c) at the commencement of this experiment was 9.1, 5.6 and 9.8 mg per 100 g soil respectively and that of the K_0 plots, at the conclusion 5.0, 3.4 and 5.4. Time had a very much greater effect on the K status than did the application of K, which had increased the exchangeable K status at (c), at the end of the experiment, by an average of only 1.7 mg per 100 g soil, due to a much higher concentration in the N_0K_1 treatment, and had little effect at the other two sites (Table 19).

The <u>average</u> annual uptake of K does not accurately present the real annual pattern since the 'apparent' percentage recovery of applied K increased from 1960 to 1964 (Table VII, p.63); while the absolute amount of K removed from the K_1 treatment was almost independant of year and generally exceeded the amount applied, that from the K_0 treatment generally decreased with time (Table 16). Assuming that the small annual deficits in exchangeable K, in the K_0 plots, are partially balanced by the release of non-exchangeable K, and that there is no residual fertiliser K, at the end of each season, the effect of fertiliser K on herbage Mg concentrations is the effect of annually applied K and is not complicated by the effects of residual K.

Per cent Mg.

Many workers (Stewart & Holmes, 1953; Bartlett, et al., 1954; Kemp, 1958; Hendriksen, 1960; Rook and Wood, 1960; Wolton, 1960; Hemingway, 1961b; Ritchie and Hemingway, 1963), have found that the application of K in fertilisers reduces the Mg concentration in herbage and have attempted to relate this decrease to hypomagnesaemia and hypomagnesaemic tetany.

In order to minimise this effect of K, Hunt et al. (1964) and Mudd et al. (1967) suggested autumn application of K. In this way, Hunt et al. successfully produced a smaller decrease in Mg concentration and a smaller increase in K concentration, in spring herbage, than with the same quantity of K applied in the spring. Although Mudd et al. obtained similar Mg concentrations in spring herbage from the autumn and spring applications of K, they were able to reduce the incidence of hypomagnesaemia with the autumn dressing.

The smallest amounts of K_2O applied per 1 lb of N, in the experiments of Hunt et al. and Mudd et al., were 0.84 lb and 1.43 lb respectively, for fairly low rates of N (50 to 60 lb N per acre). These rates of K are greater than the minimum required for optimum growth, even when grass is to be cut for conserving. Reith and Inkson et al. (1964) suggest that 0.75 lb K_2O per 1 lb N is more than adequate for regularly cut grass receiving high rates of N (about 300 lb N per acre) and grass for grazing will need considerably less K.

Hunt et al. and also Mudd et al. would have achieved similar Mg-concentrations in spring herbage, had they applied, in the spring, the amount of K equivalent to the autumn-applied K remaining in the spring. A much more satisfactory method of minimising the decrease in spring-herbage Mg from applied K, would be to apply, in the spring, the minimum amount of K required for one year's growth.

While red clover was present (1960 and 1961), K-alone increased herbage Mg at site (b) (Fig. 31), but after 1961, K-alone decreased the concentration of Mg in herbage because the large decrease in the proportion of clover, which occurred with the disappearance of red clover in 1962, removed most of the responsive fraction.

Although K-alone increased the proportion of clover in the sward at site (c), the decrease in herbage Mg, from the application of K, commenced in the first year of the experiment. In this case, applied K must have had a relatively greater effect on the concentration of Mg in the individual fractions than on the proportion of clover. The net result was that applied K consistently decreased the concentration of Mg in mixed herbage at (c). When red clover disappeared at site (c) there was sufficient white clover in the sward, till the end of the experiment, to respond to the annual application of K-alone.

Except for the effects of K-alone at site (b) in 1960 and 1961, before red clover disappeared, K_1 compared with K_0 in the remaining years at (b) but in all years at (a) and (c), produced a fairly constant decrease in Mg concentration throughout the experiment (Table IX, p.64), when the decrease is expressed as a percentage of the K_0 concentration. There appears to be no pattern within years; the decrease at cut 3 being, on average, the same as that at cut 1.

These findings appear to support the assumption that little residual K was carried over from one year to the next. They also suggest that, in these experiments, the Mg concentration in the plant is affected by the rate of applied K, but not by the concentration of K in the DM. If the concentration of K in the DM had controlled the Mg concentration, as the gap

in the K concentration between K_0 and K_1 widened with time, so inversely would the concentration of Mg.

Uptake of Mg

The application of K-alone effectively stimulated the removal of Mg at each site, particularly in the first 3 years of this series of experiments (Fig. 33).

Soil Data.

The small decrease in exchangeable Mg concentration which occurred at each site with the application of K, is the result of cation exchange. This decrease in exchangeable Mg is not associated with an equivalent increase in exchangeable K since most of this increase would have been removed by plant roots, almost as soon as it occurred.

Botanical Composition.

Heddle (1967) reported that the effect of N on botanical composition depends on whether or not K is also applied. In the absence of K, this worker found that the application of 87 lb N (as 'Nitro-Chalk') per acre per annum resulted in the complete disappearance of all clover at a very early stage, but that when K was also applied the application of the same quantity of N reduced but did not eliminate white clover. The application of K, with N, preserved clover at site (c), but not at (b) (Table 20) where there had also been a clover response to K-alone, similar to that reported by Reith and Inkson et al. (1964). These between-site differences could have been due to differences in times of cutting (see p. 82) resulting in different proportions of white clover in the swards at each of the three sites (Table 20).

Reith and Inkson et al. (1964) found that K-alone maintained, but did not increase clover, at only one site out of six, and in this series of

experiments the ratio was one out of 3. The different responses of clover to K at these 3 sites cannot be explained satisfactorily on the basis of differences in levels of exchangeable K.

Barley.

Although K reduced the Mg concentration in the July leaf samples by 12 per cent, it had little effect on the Mg concentration in grain or in straw, and had no effect on the yield of grain or on the uptake of Mg by grain. The concentration of Mg in the July leaf samples, with K_1 was only 0.10 per cent but this was sufficient for optimum growth and yield of grain.

Potatoes.

It was unfortunate that the foliage at Experiment III(i) should have been destroyed before samples could be taken for analysis.

Reductions in leaf Mg, with increasing rates of K, similar to those which occurred at Experiment III(ii) (Table 33 (a)) have been reported by many workers (Walsh and O'Donohoe, 1945; Nicholas and Catlow, 1947; McNaught, 1959; Hovland and Caldwell, 1960; Jackson and Thomas, 1960; Holmes, 1962b).

While KCl, compared with K_2SO_4, increased the concentration of Mg in the foliage at Experiment III(ii) by 7 per cent and decreased that of K by 16 per cent, the inverse relationship existed in the tubers viz. that K_2SO_4, compared with KCl, increased Mg concentration by 6 per cent and decreased K by 8 per cent. Nicholas and Catlow (1947) observed that Mg-deficiency symptoms were less on plots receiving KCl in place of K_2SO_4. In Experiment III(i) (NPKT on potatoes), type of potassium salt (T) had no effect on the Mg concentration in the tubers.

An increase in both K and Mg concentration in the tuber DM occurred in both experiments with an increase in rate of application of K. Laughlin (1966) obtained this effect in two out of 3 potato experiments (the results were not statistically significant in the third), and he suggested that this was the result of an adequate supply of soil Mg. The soil at Experiment III(ii) was 'deficient' in Mg and yet this effect occurred both with and without applied Mg.

Since applied K has already reduced the supply of Mg in the foliage, this movement of Mg from foliage already low in Mg could result in the appearance of Mg-deficiency symptoms. These symptoms either appear or become more evident in July or August, when the rate of growth of tubers and their Mg requirement is greatest. Walsh and O'Donohoe (1945) observed that when severe Mg-deficiency symptoms appeared in the foliage as a result of high rates of K, the concentration of Mg in the tubers was reduced only by a slight extent. Tuber Mg will therefore be decreased by applied K only when there is insufficient foliage Mg for the requirements of the developing tubers.

The uptake of Mg by the tubers was increased by K in both experiments. In Experiment III(i) the increase was solely due to the increase in concentration but in Experiment III(ii), K increased both yield and Mg concentration.

EFFECTS of N and K.

The main effects of N and of K and some of their interaction effects have already been discussed but this is a suitable point to summarise these interaction effects and to discuss others that seem to have been of importance in this work.

The effect of the NK interaction on the Mg concentration in mixed herbage depended on stage of growth, site and season. N, with or without K, always depressed the growth of clover, but N without K usually increased the Mg concentration of the mixed herbage at cut 1, compared with N_0K_0, because of the increased Mg concentration in the grass fraction. On the other hand K, in the presence of N, decreased the Mg concentration at cut 1. The net result of these effects was that the concentration with N_1K_1 was almost always similar to that with N_0K_0.

At sites (b) and (c) where K-alone stimulated clover, the net result of applying K, without N, on the Mg concentration of herbage was governed by the magnitude of the increase in the proportion of clover in relation to the decrease in the concentration of Mg in grass and in clover. An increase in herbage Mg occurred at site (b) at cuts 1 and 2 in 1960 (Table IV, p.57) and at cut 1 in 1961 as a result of a proportionately greater effect of K on the proportion of clover than on the Mg concentration of the individual fractions, but at all other cuts at (b) and at almost all cuts at (c), K-alone decreased herbage Mg compared with N_0K_0 because the reverse effect occurred.

There was an NK effect on the K concentration in the herbage (Fig. 30) which varied within and between years; e.g. N and K together caused an excessive intake of K at cut 1 but not at later cuts.

An NK x time interaction-effect on yield resulted in the response to N, in the absence of K, decreasing as the 'available' K supply in the soil was depleted with time. A similar effect was observed by Heddle (1967). The magnitude of the main N effect appeared to decrease with time because there was (i) a decrease in the response to N, in the absence of K, and (ii)

an increase in the response to K-alone, the net result of these two effects being a reduction in the 'apparent' response to N.

In Experiment I(ii) (Mg compounds on grass), the amount of K removed annually in the herbage was much greater than the amount applied. Because of this negative K balance, the exchangeable K concentration (mg per 100 g soil) fell from 14.6 (March 1964) to 7.6 (December 1966), while, in the same time-interval the exchangeable Mg fell from 8.6 to 7.6.

This decrease in exchangeable K allowed the herbage Mg concentration at cut 1 to increase annually (Fig. 40), and the average annual increase in Mg concentration, when expressed as a percentage of the preceeding year's Mg concentration, was almost equal to that produced by 120 lb Mg per acre as calcined magnesite. Working with pairs of soil and plant samples from a wide range of soil types, Nearpass and Drosdoff (1952) and Harding (1954) found that leaf Mg was significantly negatively correlated with the percentage saturation of K in the soil. Mehlich and Reed (1945) and Salmon (1964) artificially created a range of exchangeable K concentrations and found that, at a constant exchangeable Mg concentration, increasing K resulted in a decrease in the concentration of Mg in the plant.

Increase in Mg concentration with decrease in exchangeable K occurred in this investigation, despite the presence of about 100 lb fertiliser K per acre in the 2nd, 3rd and 4th years of this experiment, which would decrease herbage Mg. Despite this, the annual decrease in the exchangeable K:Mg ratio has increased the Mg concentration in the herbage by an amount equal in magnitude to the decrease observed in Experiment I(i) from the annual applications of similar amounts of K. This suggests that a decrease in exchangeable K:Mg ratio from 2:1 (approx.) to 1:1, can increase herbage Mg concentration to a

greater extent than a 'normal' K application can decrease it. Similar effects were not noticeable at sites (a), (b) and (c) where the exchangeable K:Mg ratios, at the beginning of the experiment were about 1:1.

The past history of hypomagnesaemia and hypomagnesaemic tetany on the farm at Experiment I(ii) could be attributed to the high exchangeable K:Mg ratio rather than the absolute Mg status of the soil. A carefully planned fertiliser programme (particularly K) for the complete rotation is therefore essential to prevent a rapid build up or depletion of exchangeable K. Redlich (1960) found that hypomagnesaemic tetany could be controlled by lowering the exchangeable K:Mg ratio from about 2 or 3:1 to 0.8 to 1.3:1, and a similar change occurred at I(ii) in 3 seasons.

While Welte and Werner (1963) suggested that the K-Mg antagonism occurs only in soils deficient in Mg, Walsh and O'Donohoe (1945) found that Mg-deficiency symptoms in plants were invariably associated with high levels of exchangeable K and never with Mg-'deficient' soils (sic). Walsh and Clarke (1945) found that Mg-deficiency symptoms which occurred in the leaves of tomato plants as a result of high levels of K could be removed by either reducing K or increasing Mg. Cromwell and Hunter (1942) and Boynton and Embleton (1950) also observed a K-Mg antagonism in soils with adequate supplies of Mg.

The NK interaction also affected the exchangeable K concentration in Experiment I(i). While N_1K_0 had a lower exchangeable K concentration in 1965 than N_0K_0 at site (c), these treatments produced similar concentrations at the other 2 sites (Table 19). The increase in exchangeable K with N_0K_1, compared with N_0K_0, was greater than with N_1K_1, the latter being just greater than N_0K_0. (Tables 19 (a) to (c)). These results are related to

the total uptake of K presented in Table VIII (p.63). As in Experiment I(ii) the total uptake of K from the K_1 plots was greater than the amount applied. The 'luxury' uptake of K, responsible for this loss, could have been prevented by the use of a less readily-available source of K.

EFFECTS of Mg.

Yield.

The effects of Mg on the yield of crops examined in this investigation were as variable and inconsistent as those reported in the literature by many workers.

Russell and Garner (1941) and Holmes (1962a) found no consistent effects of $MgSO_4$ on the yield of potatoes; yields were occasionally increased and sometimes decreased. Although Sluijsmans (1959) found that Mg increased the yield of potatoes in soils with an exchangeable Mg concentration of about 1 mg Mg per 100 g soil, there was little response (not statistically significant) to $MgSO_4$ in Experiment III(ii) (Table 35 (a)) where the exchangeable Mg level was 2.0 mg per 100 g soil.

Ferrari and Sluijsmans (1955) suggested that a yield response by oats to Mg is likely only when serious Mg-deficiency symptoms occur and that yields are rarely affected when the deficiency symptoms are slight. In Great Britain, Mg-deficiency symptoms on cereals are usually transient and Holmes (1962b) found, in almost all his cereal experiments, that Mg had not increased yield.

The following workers have found that Mg had no effect on yield: Foy and Barber (1958) with maize showing Mg-deficiency symptoms, Schachtschabel and Hoffman (1958) with ryegrass, Reith (1962) with a range of crops, and Peeler and Heafield (1966) with potatoes and sugar beet.

Most responses to Mg have been on light soils, low in Mg, where the reported increases were 5 to 20 per cent, with the average nearer 5 (Charlesworth, 1967; Edwards, 1967; Harrod and Caldwell, 1967) but Prince (1951), with one soil and various crops, reported increases of from 34 to 300 per cent.

Chemical composition.

The positive correlation between applied Mg and P uptake reported by Troug et al. (1947), Hashimoto and Kawaguchi (1955) and Seo and Ichikawa (1958) occurred consistently at site (c). Tucker and Smith (1952) suggested that this effect occurred mainly on soils of low Mg activity, but Webb et al. (1954) reported that, although omission of Mg from the nutrient solution, did not retard P absorption it did have an effect on the movement and final location of P within the plant. Thus, they suggest, Mg may act as a carrier of P; resulting in a positive relationship between these two elements in the seed and a negative one in the leaves. This explains the negative correlation between Mg and P in the leaves of maize reported by Taylor (1954) and by Dorofaeff and McNaught (1962). This suggests that similar relationships in the leaves and straw of barley in Experiment II(i) though small were real.

The effect of Mg on the K concentrations of plant materials examined in these experiments was small. At sites (b) and (c), applied Mg increased herbage K by an average of 7 per cent by replacing and thus releasing soil K, but at site (a), applied Mg decreased the concentration of K in herbage by an average of 2 per cent. Since clover did not respond to K-alone at site (a) but did at sites (b) and (c), the 'available' K supply at (a) must be considered adequate, and applied Mg would therefore decrease K

uptake by ion antagonism.

The largest decrease in K concentration (7 per cent) from applied Mg occurred in barley leaves in Experiment I(ii) (NKMg on Barley). The K requirement of the barley crop is very small and a decrease in K uptake could be expected from an amount of applied Mg which was greater than that of applied K.

The application of Mg consistently increased the Mg concentration in plant material and in Experiments I(i) and II(i), where the rate of application of Mg was either similar to or greater than that of applied K, this increase more than offset the decrease from applied K. In Experiment II(ii) (KTMg on potatoes), the decrease in foliage Mg with 175 lb K (the second-highest rate) was almost offset by the increase with 36 lb Mg.

Plant material, particularly mixed herbage, is able to absorb 'luxury' amounts of both K and Mg (Wolton, 1960; Hemingway, 1961b), and in my experiments, the former occurred much more readily than the latter, because of antagonism between Mg and other cations in the root zone. Salmon (1964) reported that at constant exchangeable K concentration, the Mg concentration in ryegrass could be doubled only when the exchangeable Mg concentration was quadrupled, and that, in soils with different exchangeable Mg, Ca and K concentrations, the Mg concentration in the grass was poorly related to exchangeable Mg. Since the increase in herbage-Mg concentration from applied Mg was 57 per cent on soils low in 'available' Mg but 21 per cent where soil Mg was adequate, Welte and Werner (1964) suggested that the quantity of 'available' Mg was another factor which affected the extent of the increase in herbage-Mg concentration with applied Mg.

Foliar application is the most efficient method of increasing the Mg

concentration in plants but it is also the most uncertain because of its dependance on favourable weather. Johnston et al. (1961) reported that 84 lb $MgSO_4$ per acre applied fortnightly in foliar sprays was more effective in increasing plant Mg in one season than 600 lb $MgSO_4$ per acre applied broadcast. A 20 per cent Epsom salt solution has been used effectively on grassland by McAllister and McConachy (1963) with no noticeable scorching of the foliage.

The application of Mg affected clover Mg, relative to grass Mg, more at site (b) than at(a)(Table 8) and although the absolute increase in the resulting Mg concentration in mixed herbage was greater at cut 3 than at cut 1, the percentage increases were similar. Since the amount of Mg that can be contained in chlorophyll and in fibre of healthy herbage is limited, increases in Mg concentration resulting from the application of Mg should occur in the cell-sap Mg. A method for fractionating Mg in plant material into chlorophyll, water-soluble and fibre Mg was described by Todd (1961b). This worker later (1962) reported that fertiliser treatments, containing N, P, K and Mg, affected the total Mg concentration in herbage, but did not apparently affect the proportion in the different fractions. However the results from Todd's experiment do not satisfactorily match this conclusion. It is the author's intention to study this aspect further.

Application of $MgSO_4$, at equivalent rates of Mg to less-soluble Mg compounds, brings about a more rapid increase in exchangeable and herbage Mg, but at equivalent rates in terms of cost, $MgSO_4$ is much less effective than magnesian limestone and calcined magnesite. Wolton (1960), Hemingway (1961a) and Reith (1967) found that when applied to the soil at rates less than 60 lb Mg per acre, $MgSO_4$ produced only small increases in herbage Mg.

The loss of $MgSO_4$ by leaching, particularly at sites (a) and (b), has been considerable. MacIntire et al. (1941) reported a recovery of between 48 and 64 per cent from $MgSO_4$ applied annually, for 10 years, at a rate equivalent to 71 lb Mg per acre per annum. In my investigation the amount of applied Mg remaining in exchangeable form in the top-soil, two years after the last application of $MgSO_4$, was only 50 per cent at sites (a) and (b) but was 90 per cent at the less-acid site (c). These differences may be due to differential leaching losses from soils of slightly different pH values; the values for sites (a), (b) and (c), at the end of the experiment, were 5.9, 6.1 and 6.6 respectively. Magnitsky and Malkov (1949) found that Mg applied to the soil surface was lost by leaching more rapidly at lower pH values. This appears to be confirmed by the fact that the percentage increase in herbage-Mg concentration was smaller at sites (a) and (b), when the application of $MgSO_4$ was discontinued in 1964 and 1965, than it had been when Mg was applied annually (1960 to 1963). Under similar conditions, the percentage increase in Mg concentration with Mg_1 at site (c) remained fairly constant throughout this experiment (Table X, p.65). Annual applications of $MgSO_4$ are therefore desirable.

The solubility of magnesium ammonium phosphate increases with decrease in soil pH (Lunt et al., 1964), and yet in Experiment I(ii) with an initial pH of 6.2, this compound applied to the soil surface, was an effective and consistent source of Mg, but there was little benefit from its high P concentration in the presence of supplementary P.

In this work, 1.2 tons of magnesian limestone per acre, applied to the surface of a soil with a pH of 6.2, increased herbage Mg in the year of application, and became more effective in subsequent years (Experiment I(ii), Table 26 (a)). Jones (1950) and MacLeod (1958) have shown that magnesian

and calciferous limestones are equally effective in neutralizing acidity when applied at equivalent 'neutralising-value' rates. Reith (1954) observed that magnesian limestone had no appreciable effect on the Mg concentration of pasture during 5 months after application but Prince (1951), Parr and Allcroft (1957), Griffiths (1959), Munk (1961) and McConaghy et al. (1963) have shown that magnesian limestone is more effective, as a liming material and source of Mg, at pH values less than 6.0.

While Cunningham (1936) found magnesian limestone to be, on average, 43 per cent as effective as Epsom salt in increasing the Mg concentration in grass at equivalent rates of Mg, Parr and Allcroft (1957) reported this effectiveness to be 32 per cent when compared with calcined magnesite.

Calcined magnesite was as effective in increasing herbage Mg in the fourth year as in the year of application, but the exchangeable Mg concentration from this treatment continued to increase during this period. The quantity of soil-Mg which is 'available' to plants is related to the exchangeable-Mg concentration (Michael and Schilling, 1957; Salmon and Arnold 1963). However, since the concentration of Mg in herbage in this experiment did not increase with the increase in exchangeable Mg which occurred with time (Figs. 38 and 43), the plants must have been able to obtain some Mg directly from calcined magnesite. Longstaff and Graham (1951) found that Mg in un-weathered magnesite and dolomite was readily available to plants.

In all experiments, the recovery of applied Mg was small and where there is hypomagnesaemia and hypomagnesaemic tetany, soil application would be a very inefficient method of increasing blood and plasma Mg. In these circumstances some method of incorporating the Mg compound directly into

the animal's diet is recommended. There may be some merit in the method suggested by McAllister and McConaghy (1964) for increasing the Mg content of spring pasture; a solution of molasses is used to aid retention by the grass of finely ground calcined magnesite.

The current cost in Edinburgh of Epsom salt, calcined magnesite and magnesian limestone (excluding the cost of its 'liming value'), per 1 lb Mg, is 2/2d, 7d and 0.56d respectively. (When the liming value of magnesian limestone is included, the cost of 1 lb Mg is 2.42d). Therefore, where hypomagnesaemia is not an immediate problem, the most economical method of preventing a 'run down' of soil Mg by leaching and removal in crops, with subsequent effects on chemical composition, animal health and crop yields, is by applying 2 tons per acre of a calciferous limestone and a good quality magnesian limestone (11 - 12 per cent Mg) alternately, once every 4 years. By this means, the exchangeable Mg concentration should be maintained at least at 15 mg per 100 g soil, which is above the critical 'deficiency-' level for a heavy soil.

VI. GENERAL DISCUSSION.

A large concentration of K in herbage (2.76 per cent) occurred at cut 1 of Experiment I(ii) in 1964, as a result of applying a relatively small quantity of fertiliser K with sufficient N for a good crop of hay, because applied N had stimulated the absorption of a large quantity of 'available' soil K. The rate of application of K in this experiment was increased in subsequent years (the rate of N was kept fairly constant throughout) and as a result even higher K concentrations were obtained at cut 1 (average 3.44 per cent).

At sites (a) and (b) in 1960, the increase in K concentration in mixed herbage, resulting from the application of K, was much greater in the presence than in the absence of applied N. This combined effect of NK on the concentration of K in herbage was not obvious at site (c) and occurred at (a) and (b) only in 1960 when there was sufficient 'available' K (soil and fertiliser) with applied N.

Similar positive NK effects on herbage K have been reported by Smyth et al. (1958), Kemp (1960), Wolton (1960) and Black and Richards (1965), where large amounts of K were applied with normal and acceptable rates of N. These workers, with the exception of Wolton who studied pasture only, found a relationship between the NK treatment and the incidence of hypomagnesaemia.

Smyth et al. (1958) found that, although N and K applied separately to herbage had no effect on the serum-Mg levels of cattle, a combined dressing of NK caused a rapid decline in serum-Mg levels followed by the onset of tetany in cattle grazing this pasture. While the NK treatment produced a similar herbage-Mg concentration to that of the control, the N and the K

treatments, the K concentration was increased much more by NK than by any other treatment.

Black and Richards (1965) found that, while N-alone had no effect on either herbage or blood serum Mg of sheep, animals grazing the NK-treated pasture had lower serum Mg only in the spring of the second year of their investigation. While the effect of NK on herbage Mg was similar in these two years, relative to the other treatments, its effect on herbage K was much greater in the second year than the first.

Brouwer (1952) found that swards which produced tetany had a greater K:(Mg+Ca+Na) ratio than 'healthy' pastures. As the result of a survey of dairy farms in South Scotland, Butler et al. (1963) found a highly-significant, linear relationship between the incidence of tetany and the ratio K:(Ca+Mg).

Mudd et al. (1965) found that cattle grazing pasture dressed with K in the autumn had higher serum-Mg levels than cattle on spring-dressed pasture. Time of application of K had no effect on the concentration of Mg in the herbage but the pasture which had received its K in the spring had a higher K concentration than that which received it in the autumn.

Hemingway et al. (1963), who applied K at realistic rates (3 cwt per acre 'Nitro-Chalk', with 0,1 and 2 cwt per acre KCl), were unable to influence the plasma-Mg level of ewes.

Although the first cut in the grassland experiments in this investigation was taken later than 'normal' for the study of hypomagnesaemic conditions, the assumption has been made that the chemical composition of the herbage at these two stages of growth will be related. Applied K, particularly in the presence of N, had a much greater effect on its own concentration in

herbage DM than on the concentration of Mg, when these effects are expressed as a percentage of the appropriate concentration with no-applied K (Figs. 27, 28 and 31).

Smyth et al. (1958), Kemp (1960) and Black and Richards (1965) found a positive relationship between the incidence of hypomagnesaemia and the K concentration of pasture, particularly when the latter was increased by N and K applied together. However, only Kemp of these workers reported a negative relationship between incidence and a reduction in herbage- and serum-Mg resulting from the application of K.

There is a suggestion, from the literature and from my work, that hypomagnesaemia may be associated with pasture having a higher K:Mg ratio than 'healthy' pasture, induced by N and K applied together. Butler et al. (1963) reported that pasture associated with tetany had a lower Mg and a higher K concentration than 'normal' pasture and that the former pastures received more N, P and K in fertilisers than the latter.

It has been shown by several workers that K influences the absorption of Mg from the stomach of animals. Care et al. (1967), using ^{28}Mg, showed that less Mg was absorbed by sheep from spring grass than from hay, supplying an equivalent amount of Mg but perhaps less K. Several workers (Kunkel et al., 1953; Meyer and Steinbeck, 1960; Kemp et al., 1961; de Groot, 1961) have found that excess K, added to experimental diets, reduced the absorption of Mg by laboratory animals. Care et al. (1967) have shown that there is a positive correlation between the rate of absorption of Mg and the K concentration from the small intestinal digesta.

All these facts suggest that K plays as big a part, in its own right, in the hypomagnesaemia epic as the element Mg.

Because of the possible interaction effect of spring-applied K, in the presence of N, on the concentration of K in herbage, and thereafter on serum-Mg levels, K should not be applied to pastures to be used for early-spring grazing. As long as there are sufficient animals to continually defoliate the pasture then 60 to 100 lb N per acre as 'Nitro-Chalk' can be applied to a grass-clover sward without reducing clover vigour (Herriott, 1968), thus retaining the valuable source of Mg in clover. The K can be applied when the dangers from hypomagnesaemia are past - in May, perhaps, when additional N will be required.

The results from this investigation (see p. 62) and from the work of Widdowson et al. (1965) indicate that the uptake of K by herbage is greatly out of proportion to any yield increase obtained. Widdowson et al. recommend that a fertiliser with an N:K ratio of 3:5 be used on pastures for cutting. This ratio supplies an amount of K which is greatly in excess of the requirement of mixed herbage and is recommended in order to prevent a 'run-down' in the soil's 'available'-K supply.

The unnecessary 'luxury' uptake of K could be prevented, in pastures for cutting, if a K fertiliser with a much lower solubility than KCl were used e.g. a complex silicate such as biotite or muscovite (Solberg, 1928; Denison et al., 1929). If soluble N were applied with the less-soluble K in amounts which provided an N:K ratio of 3:2, yields would not be reduced through insufficient K, 'luxury' uptake of K would be prevented and, because of the steady release of K from the complex silicate throughout the year, soil-K levels would be maintained.

Another method of preventing 'luxury' uptake of K, in grass which is being intensively managed, has been suggested by Clement and Hopper (1968).

In this method, no attempt is made to prevent the 'run-down' of soil K. Instead, yield is maintained by keeping the concentration of K in the DM of herbage at 2 per cent. This is done by determining the K concentration in herbage before cutting, and by using this value in conjunction with the amount of fertiliser K applied for this cut, the amount of fertiliser K for the next cut is calculated. The 'run-down' in soil K which occurs during the 'grass break' is rectified by applying additional K to the succeeding crops.

Since Mg is essential for both plants and animals, the soil reserves have to be maintained. Large dressings of Mg are necessary if one is to combat the antagonism of K, and produce realistic increases in herbage Mg. Since the application of 'lime' to most of our soils, at least once each rotation, is essential for optimum yields of healthy crops, magnesian limestone is the ideal, dual-purpose material.

At equivalent rates of Mg, calcined magnesite will increase the Mg concentration of herbage to a greater extent than magnesian limestone, particularly in the year of application. However, calcined magnesite is very much more expensive, per lb of Mg, than the limestone (see p.106). This should discourage its use as a fertiliser, since the two materials differ proportionately more in cost than in effect on herbage Mg concentration. Where there is a risk of hypomagnesaemia, calcined magnesite is a suitable mineral supplement.

Small annual dressings (30 - 60 lb Mg per acre) of $MgSO_4$ to the soil are uneconomical and inefficient since they are not able to combat effectively the antagonistic effects of K. They are also liable to considerable losses by leaching - about 50 per cent of applied $MgSO_4$ can be lost by leaching in one season.

Until further work establishes the cause of hypomagnesaemia or until other preventive measures are suggested, feeding a Mg compound such as calcined magnesite it the surest and most effective method of getting Mg into the animal. Ritchie and Hemingway (1968) tested Mg-alloy bullets in dairy cattle (86 per cent Mg, 12 per cent Al and 2 per cent Cu) and found them to be an effective means of preventing hypomagnesaemia.

To reduce the need for these measures, it is advisable to maintain an adequate level of 'available' Mg in the soil. Since an excess of one plant nutrient can be almost as bad as a deficiency, an unnecessary 'build-up' of Mg in the soil should be prevented. This 'build-up' could occur through the continued use of magnesian limestone and it may therefore be safer to alternate between a magnesian and a calciferous limestone when liming is necessary. By this means, the 'available' soil Mg should be maintained at a level (>15 mg per 100 g soil) which is adequate for all soil types and crops.

VII. SUMMARY AND CONCLUSIONS.

Five field experiments were carried out between 1960 and 1967 to study the effects of fertilisers containing N, K and Mg on the yield and chemical composition of grass, clover, mixed herbage, barley and potatoes and on the exchangeable-Mg concentration in the soil. Two of the experiments were on grassland, two were on potatoes and one was on barley. One of the grassland experiments was carried out at three sites but the remainder were 'single-site' experiments. The grassland experiments were continued for four or six years.

The results and the conclusions may be summarised as follows:-

(1). While applied N, as $(NH_4)_2SO_4$, and K, as KCl, had a proportionately greater effect on herbage Mg than on exchangeable soil-Mg, the reverse occurred with applied Mg as $MgSO_4$.

(2). Early in the season, clover contained four times as much Mg in the DM as grass and although this factor decreased with time, the minimum value was still greater than two.

(3). Applied N increased the yield of grass and depressed that of clover, but since the clover contained at least twice as much Mg as grass, applied N reduced the uptake of Mg by mixed herbage.

Applied N had no effect on the Mg concentration in barley grain, but increased yield and thus the uptake of Mg by the grain.

(4). In the absence of applied N, applied K increased clover vigour at two out of three sites.

Applied K consistently decreased the concentration of Mg in grass and in clover.

As the result of the large increase in the proportion of clover at one site, from the application of K-alone, an increase in the Mg concentration of mixed herbage occurred, even although the Mg concentration in both the grass and the clover had been decreased.

(5). An increase in the rate of application of K decreased the concentration of Mg in potato foliage (KCl reduced the concentration less than K_2SO_4) and increased the concentration and uptake of Mg in tubers (K_2SO_4 increased the Mg concentration in tubers more than KCl).

(6). An increase in the Mg concentration in mixed herbage occurred when the exchangeable K:Mg ratio was reduced from 2:1 to 1:1, with almost constant exchangeable Mg.

(7). Applied K had a proportionately greater effect on its own concentration in herbage, because of 'luxury' uptake, than on the concentration of Mg. These effects are discussed in relation to hypomagnesaemia.

(8). The application of Mg, in different compounds, had little effect on yield, compared with no Mg.

(9). At equivalent rates of Mg, increases in herbage-Mg concentration and exchangeable soil-Mg were in the order:-

Epsom salt > calcined magnesite > magnesian limestone.

When these compounds are applied at equivalent rates in terms of cost, the above order is reversed. Magnesian limestone is therefore recommended as a source of Mg for maintaining an adequate 'available' Mg-supply for all crops and also as a 'liming' material.

(10). Since the percentage 'apparent' recovery of applied Mg is small, the application of a magnesium compound, such as Epsom salt or calcined magnesite,

to a pasture which is capable of inducing hypomagnesaemia in ruminants, is considered an uneconomical method of increasing the level of Mg in blood serum.

Application of Mg to the soil is not a reliable method of increasing the Mg concentration of such pastures because of ion antagonism. When similar quantities of K and of Mg (about 100 lb per acre per annum of each element) were applied separately to grassland, the percentage decrease in herbage Mg concentration resulting from the application of K was generally just smaller in magnitude than the increase which occurred from the application of Mg. The Mg concentration in herbage with K and Mg applied together was only slightly greater than that without either K or Mg.
(11). About 50 per cent of applied $MgSO_4$ can be lost from the top-soil by leaching during one year.

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X. APPENDIX.

RESULTS of EXPERIMENTS.

Experiment I(ii) - Mg Compounds on Grass, 1960-1964.

Experiment II(i) - NKMg on Barley, 1961.

Experiment III(i) - NPKT on Potatoes, 1961.

Experiment III(ii) - KTMg on Potatoes, 1964.

TABLE 1(a). EXPERIMENT I(i). KINGSIDE, 1960. Yield of Dry Matter (cwt per acre).

EFFECT	GRASS				CLOVER				MIXED HERBAGE			
	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	9.3	8.0	3.2	20.5	0.8	12.0	8.4	21.2	10.0	20.1	11.5	41.6
N_1	32.4	12.6	3.4	48.4	0.6	1.7	2.8	5.1	33.1	14.2	6.2	53.5
N_1-N_0	23.1***	4.6*	0.2*	27.9***	-0.2	-10.3***	-5.6**	-16.1***	23.1***	-5.9*	-5.3**	11.9*
K_0	20.4	10.3	2.9	33.6	0.7	7.3	5.4	13.4	21.1	17.6	8.4	47.1
K_1	21.3	10.3	3.6	35.2	0.7	6.4	5.8	12.9	22.0	16.7	9.3	48.0
K_1-K_0	0.9	0	0.7**	1.6	0	-0.9	0.4	-0.5	0.9	-0.9	0.9	0.9
S.E.± (Difference)	0.70	1.12	0.06	1.74	0.15	0.47	0.74	0.58	0.67	1.27	0.70	2.12
NK Interaction												
N_0K_0	8.6	7.9	2.7	19.2	0.8	12.7	8.1	21.6	9.4	20.5	10.8	40.7
N_1K_0	32.2	13.2	3.2	48.6	0.6	2.0	2.7	5.3	32.8	15.2	5.9	53.9
N_0K_1	10.0	8.2	3.6	21.8	0.7	11.4	8.7	20.8	10.7	19.7	12.3	42.7
N_1K_1	32.6	11.9	3.6	48.1	0.7	1.4	2.9	5.0	33.3	13.3	6.4	53.0
S.E.± (Difference)	0.99	1.58	0.09	2.47	0.22	0.67	1.05	0.83	0.94	1.79	0.99	3.00
Mg_0	21.1	10.5	2.9	34.5	0.6	6.7	5.5	12.8	21.7	17.2	8.3	47.2
Mg_1	20.6	10.1	3.6	34.3	0.8	7.1	5.7	13.6	21.4	17.0	9.4	47.8
Mg_1-Mg_0	-0.5	-0.4	0.7***	-0.2	0.2	0.4	0.2	0.8	-0.3	-0.2	1.1	0.6
S.E.± (Difference)	1.13	0.55	0.12	1.54	0.21	0.39	0.67	0.88	1.07	0.57	0.70	1.50

TABLE 1(b). EXPERIMENT I(i). SHARPLAW, 1960 Yield of Dry Matter (cwt per acre)

EFFECT	GRASS				CLOVER				MIXED HERBAGE			
	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	12.6	10.7	5.1	28.4	1.1	9.1	14.7	24.9	13.6	19.8	19.8	53.2
N_1	33.8	14.4	4.4	52.6	0.8	1.5	6.4	8.7	34.5	15.9	10.8	61.2
N_1-N_0	21.2**	3.7	-0.7	24.2**	-0.3	-7.6**	-8.3*	-16.2*	20.9***	-3.9	-9.0	8.0
K_0	22.7	13.8	5.5	42.0	0.7	3.5	8.5	12.7	23.4	17.3	14.0	54.7
K_1	23.7	11.3	4.0	39.0	1.1	7.1	12.5	20.7	24.8	18.4	16.6	59.8
K_1-K_0	1.0	-2.5	-1.5	-3.0	0.4	3.6*	4.0	8.0	1.4	1.1	2.6	5.1
S.E.± (Difference)	1.28	1.78	1.28	3.50	0.22	0.91	2.46	3.37	1.40	2.51	3.52	6.56
NK Interaction												
N_0K_0	12.1	12.7	6.4	31.2	0.6	5.7*	11.0	17.3	12.8	18.3	17.4	48.5
N_1K_0	33.2	15.0	4.7	52.9	0.8	1.3	5.9	8.0	33.9	16.3	10.5	60.7
N_0K_1	13.0	8.8	3.9	25.7	1.5	12.6	18.3	32.4	14.5	21.4	22.2	58.1
N_1K_1	34.4	13.8	4.2	52.4	0.7	1.6	6.8	9.1	35.1	15.4	11.0	61.5
S.E.± (Difference)	1.80	2.52	1.81	4.95	0.31	1.29	3.48	4.76	1.98	3.55	4.98	9.29
Mg_0	22.5	11.5	4.5	38.5	0.8	5.5	10.9	17.2	23.3	16.9	15.3	55.5
Mg_1	23.8	13.7	5.1	42.6	1.0	5.1	10.1	16.2	24.8	18.8	15.2	58.8
Mg_1-Mg_0	1.3	2.2*	0.6	4.1*	0.2*	-0.4	-0.8	-1.0	1.5	1.9	-0.1	3.3
S.E.± (Difference)	1.04	0.78	0.24	1.39	0.07	0.54	0.89	0.70	1.05	1.00	0.74	1.42

TABLE 2(a). EXPERIMENT I(i). KINGSIDE, 1960. Per cent N in DM.

EFFECT	GRASS Cut 1	GRASS Cut 2	GRASS Cut 3	CLOVER Cut 1 [1]	CLOVER Cut 2	CLOVER Cut 3	MIXED HERBAGE Cut 1 [2]	MIXED HERBAGE Cut 2	MIXED HERBAGE Cut 3
N_0	1.39	1.14	2.37		2.39	3.93		1.88	3.51
N_1	2.01	1.06	2.06		2.75	3.91		1.28	2.88
N_1-N_0	0.62**	-0.08	-0.31**		0.36**	-0.02		-0.60**	-0.63**
K_0	1.71	1.08	2.23		2.60	3.95		1.60	3.24
K_1	1.70	1.12	2.20		2.54	3.89		1.56	3.15
K_1-K_0	-0.01	0.04	-0.03		-0.06	-0.06		-0.04	-0.09
S.E.± (Difference)	0.048	0.037	0.031		0.048	0.057		0.060	0.049
NK Interaction									
N_0K_0	1.38	1.14	2.40		2.46	3.96		1.95	3.57
N_1K_0	2.04	1.02	2.06		2.75	3.94		1.25	2.91
N_0K_1	1.41	1.14	2.33		2.32	3.90		1.82	3.44
N_1K_1	1.98	1.11	2.06		2.76	3.87		1.30	2.86
S.E.± (Difference)	0.068	0.052	0.044		0.067	0.080		0.085	0.070
Mg_0	1.76	1.09	2.24		2.54	3.93		1.54	3.22
Mg_1	1.64	1.11	2.19		2.60	3.90		1.62	3.17
Mg_1-Mg_0	-0.12	0.02	-0.05		0.06	-0.03		0.08	-0.05
S.E.± (Difference)	0.059	0.033	0.048		0.055	0.056		0.054	0.086

1. Insufficient material for a chemical analysis.
2. Similar to GRASS, Cut 1.

TABLE 2(b). EXPERIMENT I(i). SHARPLAW, 1960. Per cent N in DM.

EFFECT	GRASS Cut 1	GRASS Cut 2	GRASS Cut 3	CLOVER[1] Cut 1	CLOVER Cut 2	CLOVER Cut 3	MIXED HERBAGE[2] Cut 1	MIXED HERBAGE Cut 2	MIXED HERBAGE Cut 3
N_0	1.29	1.20	2.28		3.15	3.40		2.06	3.07
N_1	2.01	1.17	1.81		3.39	3.77		1.37	2.90
N_1-N_0	0.72***	-0.03	-0.47**		0.24	0.37		-0.69**	-0.17
K_0	1.69	1.19	1.97		3.36	3.67		1.61	2.92
K_1	1.60	1.17	2.12		3.18	3.49		1.82	3.05
K_1-K_0	-0.09*	-0.02	0.15		-0.18	-0.18		0.21	0.13
S.E.± (Difference)	0.022	0.052	0.065		0.117	0.176		0.074	0.100
NK Interaction									
N_0K_0	1.32	1.19	2.11		3.28	3.57		1.83*	3.06
N_1K_0	2.06	1.20	1.82		3.45	3.78		1.39	2.79
N_0K_1	1.25	1.22	2.45		3.02	3.22		2.28	3.09
N_1K_1	1.96	1.13	1.80		3.33	3.76		1.35	3.01
S.E.± (Difference)	0.031	0.073	0.093		0.166	0.249		0.104	0.148
Mg_0	1.57	1.17	2.09		3.30	3.57		1.75	3.03
Mg_1	1.72	1.19	2.00		3.24	3.60		1.68	2.94
Mg_1-Mg_0	0.15*	0.02	-0.09		-0.06	0.03		-0.07	-0.09
S.E.± (Difference)	0.045	0.031	0.070		0.047	0.037		0.034	0.047

1. Insufficient material for a chemical analysis.

2. Similar to GRASS, Cut 1

TABLE 3(a) EXPERIMENT I(i). KINGSIDE, 1960. Uptake of N (lb per acre)

EFFECT	GRASS				CLOVER				MIXED HERBAGE			
	Cut 1	Cut 2	Cut 3	Total	Cut 1 [1.]	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	14.5	10.3	8.3	33.1		32.2	37.0	70.3	15.6	42.5	45.3	103.4
N_1	73.2	14.9	7.7	95.8		5.2	12.2	18.8	74.6	20.1	19.9	114.6
N_1-N_0	58.7***	4.6*	-0.6*	62.7***		-27.0***	-24.8**	-51.5***	59.0***	-22.4*	-25.4**	11.2
K_0	43.6	12.2	7.3	63.1		20.4	24.0	45.7	44.9	32.7	31.3	108.9
K_1	44.1	12.9	8.8	65.8		17.0	25.1	43.5	45.4	29.9	33.9	109.2
K_1-K_0	0.5	0.7	1.5**	2.7		-3.4	1.1	-2.2	0.5	-2.8	2.6	0.3
S.E.± (Difference)	2.90	1.33	0.17	3.93		1.44	3.07	3.31	2.70	2.38	2.98	6.22
NK Interaction												
N_0K_0	13.2	10.0	7.3	30.5		34.8	36.0	72.0	14.4	44.7	43.3	102.4
N_1K_0	74.0	14.5	7.3	95.8		6.0	11.9	19.2	75.3	20.6	19.2	115.1
N_0K_1	15.7	10.6	9.3	35.6		29.7	37.9	68.7	16.8	40.2	47.2	104.2
N_1K_1	72.5	15.2	8.2	95.9		4.4	12.4	18.2	73.9	19.6	20.6	114.1
S.E.± (Difference)	4.10	1.88	0.24	5.56		2.04	4.34	4.68	3.82	3.36	4.21	8.80
Mg_0	46.7	12.7	7.2	66.6		18.0	23.9	43.1	47.9	30.6	31.2	109.7
Mg_1	41.0	12.4	8.8	62.2		19.5	25.2	46.1	42.4	31.9	34.0	108.3
Mg_1-Mg_0	-5.7	-0.3	1.6**	-4.4		1.5	1.3	3.0	-5.5	1.3	2.8	-1.4
S.E.± (Difference)	4.56	0.78	0.39	4.80		1.02	2.76	3.46	4.47	1.60	2.83	4.81

1. Insufficient material for a chemical analysis.

TABLE 3(b). EXPERIMENT I(i). SHARPLAW, 1960 Uptake of N (lb per acre).

	GRASS				CLOVER				MIXED HERBAGE			
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1[1]	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	18.1	14.6	12.8	45.5		31.6	54.8	87.9	19.6	46.2	67.6	133.4
N_1	76.0	18.9	6.9	103.8		5.5	26.3	33.4	77.6	24.3	35.3	137.2
N_1-N_0	57.9***	4.3	-3.9	58.3**		-26.1**	-28.5*	-54.5*	58.0***	-21.9*	-32.3	3.8
K_0	47.4	18.7	12.3	78.4		12.8	33.9	48.0	48.7	31.5	46.2	126.4
K_1	46.7	14.8	9.5	71.0		24.2	47.2	73.3	48.6	39.0	56.7	144.3
K_1-K_0	-0.7	-3.9	-2.8	-7.4		11.4*	13.3	25.3	-0.1	7.5	10.5	17.9
S.E.± (Difference)	2.70	2.79	3.26	6.78		3.18	8.75	11.73	2.74	5.66	11.48	17.16
NK Interaction												
N_0K_0	18.0	17.2	15.1	50.3		20.7*	43.8	65.4	18.9	37.9	58.9	115.7
N_1K_0	76.7	20.2	9.4	106.3		5.0	24.0	30.7	78.4	25.2	33.4	137.0
N_0K_1	18.2	12.1	10.6	40.9		42.4	65.8	110.3	20.3	54.5	76.3	151.1
N_1K_1	75.3	17.5	8.4	101.2		6.0	28.7	36.3	76.9	23.5	37.1	137.5
S.E.± (Difference)	3.82	3.95	4.62	9.59		4.49	12.38	16.59	3.88	8.00	16.23	24.27
Mg_0	43.2	15.0	10.4	68.6		19.3	41.9	62.6	44.6	34.3	52.3	131.2
Mg_1	50.9	18.5	11.4	80.8		17.8	39.3	58.9	52.7	36.2	50.6	139.5
Mg_1-Mg_0	7.7***	3.5	1.0**	12.2***		-1.5	-2.6	-3.7	8.1***	1.9	-1.7	8.3*
S.E.± (Difference)	0.71	1.34	0.20	1.62		1.50	3.23	2.44	0.76	2.09	3.11	2.92

1. Insufficient material for a chemical analysis.

TABLE 4(a). EXPERIMENT I(i). KINGSIDE, 1960. Per cent P in DM.

	GRASS			CLOVER			MIXED HERBAGE (3.)		
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1[1]	Cut 2	Cut 3	Cut 1[2]	Cut 2	Cut 3
N_0	0.251	0.234	0.426		0.146	0.274		0.181	0.316
N_1	0.248	0.205	0.360		0.155	0.253		0.199	0.312
N_1-N_0	-0.003	-0.029	-0.066*		0.009	-0.021		0.018	-0.004
K_0	0.248	0.216	0.394		0.153	0.267		0.187	0.314
K_1	0.251	0.223	0.391		0.147	0.260		0.190	0.314
K_1-K_0	0.003	0.007	-0.003		-0.006	-0.007		0.003	0
S.E.± (Difference)	0.0175	0.0100	0.0114		0.0030	0.0103			
NK Interaction									
N_0K_0	0.247	0.234	0.440		0.152	0.276			
N_1K_0	0.249	0.198	0.349		0.155	0.259			
N_0K_1	0.255	0.235	0.411		0.140	0.272			
N_1K_1	0.247	0.211	0.371		0.155	0.247			
S.E.± (Difference)	0.0247	0.0141	0.0161		0.0043	0.0145			
Mg_0	0.255	0.216	0.395		0.149	0.263		0.186	0.312
Mg_1	0.244	0.223	0.391		0.152	0.264		0.191	0.316
Mg_1-Mg_0	-0.011	0.007	-0.004		0.003	0.001		0.005	0.004
S.E.± (Difference)	0.0041	0.0060	0.0082		0.0032	0.0035			

1. Insufficient material for a chemical analysis.
2. Similar to GRASS, Cut 1
3. Not statistically analysed.

TABLE 4(b). EXPERIMENT I(i). SHARPLAW, 1960. Per cent P in DM

EFFECT	GRASS Cut 1	GRASS Cut 2	GRASS Cut 3	CLOVER Cut 1 [1.]	CLOVER Cut 2	CLOVER Cut 3	MIXED HERBAGE [2.] Cut 1	MIXED HERBAGE Cut 2	MIXED HERBAGE Cut 3 [3.]
N_0	0.252	0.238	0.467		0.232	0.283		0.234	0.323
N_1	0.330	0.209	0.383		0.222	0.275		0.211	0.316
N_1-N_0	0.078***	-0.029	-0.084*		-0.010	-0.008		-0.023	-0.007
K_0	0.292	0.226	0.393		0.231	0.281		0.229	0.322
K_1	0.289	0.221	0.457		0.223	0.276		0.218	0.318
K_1-K_0	-0.003	-0.005	0.064		-0.008	-0.005		-0.011	-0.004
S.E.± (Difference)	0.0034	0.0131	0.0250		0.0088	0.0076			
NK Interaction									
N_0K_0	0.254	0.237	0.413		0.242	0.290			
N_1K_0	0.331	0.216	0.374		0.221	0.273			
N_0K_1	0.250	0.239	0.521		0.223	0.275			
N_1K_1	0.328	0.203	0.392		0.223	0.277			
S.E.± (Difference)	0.0048	0.0185	0.0353		0.0125	0.0108			
Mg_0	0.287	0.229	0.433		0.234	0.277		0.229	0.320
Mg_1	0.295	0.218	0.417		0.220	0.281		0.219	0.321
Mg_1-Mg_0	0.008*	-0.011*	-0.016		-0.014	0.004		-0.010	0.001
S.E.± (Difference)	0.0024	0.0037	0.0140		0.0051	0.0062			

1. Insufficient material for a chemical analysis
2. Similar to GRASS, Cut 1
3. Not statistically analysed.

TABLE 5(a). EXPERIMENT I(i). KINGSIDE, 1960 Uptake of P (lb per acre).

EFFECT	GRASS				CLOVER				MIXED HERBAGE			
	Cut 1	Cut 2	Cut 3	Total	Cut 1 [1.]	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	2.6	2.1	1.5	6.2		2.0	2.6	4.8	2.8	4.1	4.1	11.0
N_1	9.0	2.9	1.4	13.3		0.3	0.8	1.3	9.2	3.2	2.2	14.6
N_1-N_0	6.4**	0.8	-0.1*	7.1**		-1.7***	-1.8**	-3.5**	6.4**	-0.9	-1.9**	3.6
K_0	5.7	2.5	1.3	9.5		1.2	1.7	3.1	5.9	3.7	2.9	12.5
K_1	5.9	2.5	1.6	10.0		1.0	1.7	2.9	6.1	3.6	3.3	13.0
K_1-K_0	0.2	0	0.3**	0.5		-0.2	0	-0.2	0.2	-0.1	0.4	0.5
S.E.± (Difference)	0.75	0.36	0.03	1.08		0.09	0.25	0.27	0.74	0.40	0.27	1.23
NK Interaction												
N_0K_0	2.4	2.1	1.3	5.8		2.1	2.5	4.8	2.6	4.2	3.9	10.7
N_1K_0	9.0	2.9	1.2	13.1		0.3	0.8	1.3	9.2	3.2	2.0	14.4
N_0K_1	2.8	2.2	1.7	6.7		1.8	2.7	4.7	3.0	4.0	4.3	11.3
N_1K_1	9.0	2.9	1.5	13.4		0.3	0.8	1.3	9.2	3.1	2.3	14.6
S.E.± (Difference)	1.06	0.51	0.04	1.53		0.12	0.35	0.38	1.04	0.56	0.38	1.74
Mg_0	6.0	2.5	1.3	9.8		1.1	1.6	2.9	6.2	3.6	2.9	12.7
Mg_1	5.6	2.5	1.6	9.7		1.2	1.7	3.1	5.8	3.7	3.3	12.8
Mg_1-Mg_0	-0.4	0	0.3**	-0.1		0.1	0.1	0.2	-0.4	0.1	0.4	0.1
S.E.± (Difference)	0.44	0.14	0.06	0.50		0.07	0.22	0.26	0.42	0.18	0.23	0.50

1. Insufficient material for a chemical analysis.

TABLE 5(b). EXPERIMENT I(i). SHARPLAW, 1960 Uptake of P (lb per acre).

EFFECT	GRASS				CLOVER[1]				MIXED HERBAGE			
	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	3.5	2.9	2.6	9.0		2.3	4.6	7.2	3.8	5.2	7.2	16.2
N_1	12.5	3.4	1.9	17.8		0.4	1.9	2.5	12.7	3.8	3.8	20.3
N_1-N_0	9.0***	0.5	-0.7	8.8**		-1.9**	-2.7*	-4.7*	8.9***	-1.4	-3.4	4.1
K_0	7.9	3.5	2.4	13.8		0.9	2.7	3.8	8.1	4.4	5.1	17.6
K_1	8.1	2.7	2.0	12.8		1.8	3.9	6.1	8.5	4.5	5.9	18.9
K_1-K_0	0.2	-0.8	-0.4	-1.0		0.9*	1.2	2.3	0.4	0.1	0.8	1.3
S.E.± (Difference)	0.40	0.55	0.54	1.31		0.20	0.73	0.95	0.43	0.74	1.21	2.16
NK Interaction												
N_0K_0	3.5	3.4	2.9	9.7		1.5*	3.6	5.3	3.6	4.9	6.4	14.9
N_1K_0	12.3	3.6	1.9	17.8		0.3	1.7	2.4	12.6	3.9	3.7	20.2
N_0K_1	3.6	2.3	2.2	8.2		3.1	5.6	9.2	4.1	5.4	7.9	17.4
N_1K_1	12.6	3.2	1.8	17.6		0.4	2.1	2.8	12.9	3.6	4.0	20.5
S.E.± (Difference)	0.56	0.77	0.76	1.85		0.29	1.03	1.35	0.61	1.05	1.71	3.05
Mg_0	7.6	2.9	2.1	12.6		1.4	3.4	5.1	7.9	4.3	5.5	17.7
Mg_1	8.4	3.4	2.3	14.1		1.3	3.2	4.8	8.7	4.6	5.5	18.8
Mg_1-Mg_0	0.8	0.5	0.2*	1.5**		-0.1	-0.2	-0.3	0.8	0.3	0	1.1*
S.E.± (Difference)	0.34	0.20	0.07	0.39		0.13	0.20	0.15	0.34	0.21	0.15	0.38

1. Insufficient material for a chemical analysis.

TABLE 6(a). EXPERIMENT I(i). KINGSIDE, 1960. Per cent K in DM.

EFFECT	GRASS			CLOVER			MIXED HERBAGE		
	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	2.09	1.38	3.52	2.81	1.47	2.12	2.14	1.42	2.50
N_1	2.53	1.14	3.01	2.94	1.26	1.46	2.54	1.14	2.30
N_1-N_0	0.44*	-0.24*	-0.51*	0.13	-0.21	-0.66*	0.40*	-0.28*	-0.20
K_0	2.00	1.17	3.08	2.32	1.03	1.35	2.02	1.10	2.05
K_1	2.61	1.35	3.45	3.43	1.69	2.24	2.66	1.46	2.75
K_1-K_0	0.61**	0.18	0.37*	1.11**	0.66**	0.89*	0.64**	0.36**	0.70*
S.E.± (Difference)	0.083	0.063	0.096	0.143	0.080	0.201	0.085	0.052	0.181
NK Interaction									
N_0K_0	1.97*	1.31	3.32	2.18	1.15	1.66	1.99*	1.21	2.07
N_1K_0	2.04	1.02	2.85	2.45	0.91	1.04	2.04	0.99	2.02
N_0K_1	2.20	1.44	3.72	3.44	1.78	2.58	2.28	1.63	2.92
N_1K_1	3.02	1.26	3.18	3.43	1.61	1.89	3.03	1.29	2.58
S.E.± (Difference)	0.118	0.089	0.136	0.203	0.113	0.284	0.120	0.073	0.256
Mg_0	2.33	1.22	3.23	2.87	1.36	1.81	2.36	1.25	2.40
Mg_1	2.28	1.30	3.30	2.89	1.36	1.77	2.31	1.31	2.40
Mg_1-Mg_0	-0.05	0.08	0.07	0.02	0	-0.04	-0.05	0.06	0
S.E.± (Difference)	0.030	0.035	0.062	0.029	0.070	0.083	0.031	0.039	0.082

TABLE 6(b). EXPERIMENT I(i). SHARPLAW, 1960 Per cent K in DM

EFFECT	GRASS			CLOVER			MIXED HERBAGE		
	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	1.94	1.45	3.02	1.72	1.18	1.19	1.94	1.33	1.64
N_1	2.06	1.06	2.47	1.59	0.83	0.89	2.05	1.05	1.55
N_1-N_0	0.12	-0.39	-0.55	-0.13	-0.35	-0.30	0.11	-0.28	-0.09
K_0	1.71	1.14	2.44	1.23	0.83	0.88	1.69	1.07	1.50
K_1	2.30	1.37	3.05	2.08	1.17	1.20	2.30	1.31	1.68
K_1-K_0	0.59	0.23	0.61*	0.85*	0.34	0.32	0.61*	0.24	0.18
S.E.± (Difference)	0.190	0.187	0.187	0.185	0.142	0.133	0.187	0.174	0.099
NK Interaction									
N_0K_0	1.80	1.26	2.52	1.14	0.93	1.00	1.77	1.16	1.52
N_1K_0	1.61	1.01	2.35	1.31	0.74	0.77	1.61	0.99	1.48
N_0K_1	2.08	1.63	3.52	2.30	1.43	1.39	2.11	1.51	1.75
N_1K_1	2.51	1.12	2.59	1.87	0.91	1.00	2.50	1.10	1.61
S.E.± (Difference)	0.269	0.264	0.264	0.261	0.201	0.188	0.265	0.246	0.140
Mg_0	2.02	1.26	2.78	1.54	1.03	1.02	2.01	1.18	1.54
Mg_1	1.98	1.25	2.71	1.77	0.97	1.06	1.98	1.20	1.64
Mg_1-Mg_0	-0.04	-0.01	-0.07	0.23*	-0.06	0.04	-0.03	0.02	0.10
S.E.± (Difference)	0.063	0.023	0.137	0.071	0.075	0.091	0.061	0.032	0.055

TABLE 7(a). EXPERIMENT I(i). KINGSIDE, 1960. Uptake of K (lb per acre).

EFFECT	GRASS				CLOVER				MIXED HERBAGE			
	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	21.7	12.4	12.5	46.6	2.3	19.3	20.0	41.6	24.0	31.7	32.5	88.2
N_1	92.0	15.9	11.4	119.3	2.1	2.2	4.5	8.8	94.0	18.1	15.9	128.0
N_1-N_0	70.3***	3.5	-1.1	72.7***	-0.2	-17.1**	-15.5**	-32.8**	70.0***	-13.6	-16.6***	39.8*
K_0	46.2	13.0	10.1	69.3	1.8	9.0	9.1	19.9	48.0	22.0	19.2	89.2
K_1	67.5	15.3	13.8	96.6	2.6	12.5	15.4	30.5	70.1	27.9	29.2	127.2
K_1-K_0	21.3*	2.3	3.7**	27.3*	0.8	3.5	6.3*	10.6*	22.1*	5.9	10.0**	38.0*
S.E.± (Difference)	4.56	1.28	0.35	5.32	0.43	1.68	1.39	3.18	4.40	2.79	1.16	7.29
NK Interaction	*		*						*		*	
N_0K_0	18.9	11.4	10.1	40.4	2.0	16.1	15.1	33.2	20.9	27.5	25.1	73.5
N_1K_0	73.5	14.6	10.1	98.2	1.6	1.9	3.2	6.7	75.1	16.5	13.3	104.9
N_0K_1	24.5	13.4	14.9	52.8	2.6	22.6	24.9	50.1	27.2	36.0	39.8	103.0
N_1K_1	110.4	17.3	12.6	140.3	2.5	2.5	5.9	10.9	113.0	19.7	18.5	151.2
S.E.± (Difference)	6.44	1.81	0.50	7.52	0.61	2.38	1.96	4.49	6.23	3.94	1.64	10.31
Mg_0	59.2	13.8	10.4	83.4	1.9	10.8	12.4	25.1	61.1	24.6	22.8	108.5
Mg_1	54.5	14.4	13.4	82.3	2.5	10.8	12.1	25.4	57.0	25.2	25.6	107.8
Mg_1-Mg_0	-4.7	0.6	3.0***	-1.1	0.6	0	-0.3	0.3	-4.1	0.6	2.8	-0.7
S.E.± (Difference)	2.21	0.72	0.54	2.06	0.77	0.41	1.22	1.96	2.00	1.00	1.39	2.91

TABLE 7(b). EXPERIMENT I(i). SHARPLAW, 1960. Uptake of K (lb per acre).

EFFECT	GRASS				CLOVER				MIXED HERBAGE			
	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	27.4	17.4	16.5	61.3	2.4	13.1	20.8	36.3	29.8	30.5	37.2	97.5
N_1	78.1	17.3	12.1	107.5	1.3	1.4	6.6	9.3	79.4	18.8	18.6	116.8
N_1-N_0	50.7**	-0.1	-4.4	46.2	-1.1	-11.7**	-14.2*	-27.0*	49.6**	-11.7	-18.6	19.3
K_0	42.1	18.0	14.9	75.0	1.0	3.7	9.4	14.1	43.1	21.7	24.3	89.1
K_1	63.4	16.7	13.6	93.7	2.7	10.8	18.0	31.5	66.2	27.6	31.6	125.4
K_1-K_0	21.3*	-1.3	-1.3	18.7	1.7*	7.1*	8.6	17.4	23.1*	5.9	7.3	36.3
S.E.± (Difference)	6.06	5.00	3.97	14.66	0.50	1.78	3.80	5.79	6.45	6.48	7.67	20.33
NK Interaction												
N_0K_0	24.6	18.6	17.8	61.0	0.9	6.2*	13.3	20.4	25.5	24.8	31.1	81.4
N_1K_0	59.5	17.4	12.0	88.9	1.2	1.2	5.4	7.8	60.7	18.6	17.4	96.7
N_0K_1	30.3	16.1	15.1	61.5	3.9	20.0	28.3	52.2	34.2	36.2	43.4	113.8
N_1K_1	96.6	17.3	12.1	126.0	1.5	1.7	7.7	10.9	98.1	19.0	19.9	137.0
S.E.± (Difference)	8.56	7.07	5.61	20.74	0.70	2.52	5.37	8.19	9.12	9.17	10.85	28.75
Mg_0	51.8	15.7	13.5	81.0	1.4	7.3	13.4	22.1	53.3	23.0	26.9	103.2
Mg_1	53.6	19.0	15.1	87.7	2.3	7.3	13.9	23.5	55.9	26.2	29.0	111.1
Mg_1-Mg_0	1.8	3.3	1.6***	6.7	0.9**	0	0.5	1.4	2.6	3.2	2.1	7.9
S.E.± (Difference)	2.91	1.50	0.11	3.65	0.17	0.30	1.85	1.90	2.94	1.30	1.77	4.50

TABLE 8 (a). EXPERIMENT I(i). KINGSIDE, 1960 Per cent Mg in DM.

EFFECT	GRASS			CLOVER			MIXED HERBAGE		
	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	0.117	0.155	0.218	0.449	0.435	0.433	0.142	0.322	0.375
N_1	0.154	0.155	0.210	0.378	0.558	0.495	0.158	0.207	0.340
N_1-N_0	0.037**	0	-0.008	-0.071*	0.123**	0.062*	0.016**	-0.115**	-0.035
K_0	0.138	0.159	0.223	0.444	0.573	0.500	0.157	0.298	0.385
K_1	0.132	0.151	0.204	0.383	0.420	0.428	0.144	0.231	0.330
K_1-K_0	-0.006	-0.008	-0.019	-0.061*	-0.153**	-0.072*	-0.013*	-0.067*	-0.055*
S.E.± (Difference)	0.0039	0.0067	0.0107	0.0123	0.0189	0.0138	0.0023	0.0173	0.0169
NK Interaction									
N_0K_0	0.117	0.163	0.225	0.482	0.493	0.458	0.149	0.368	0.400
N_1K_0	0.159	0.156	0.222	0.407	0.653	0.542	0.164	0.228	0.370
N_0K_1	0.116	0.147	0.211	0.416	0.376	0.408	0.136	0.276	0.350
N_1K_1	0.148	0.154	0.198	0.350	0.464	0.449	0.152	0.187	0.310
S.E.± (Difference)	0.0055	0.0094	0.0151	0.0175	0.0267	0.0195	0.0032	0.0244	0.0239
Mg_0	0.123	0.142	0.201	0.366	0.458	0.430	0.135	0.238	0.335
Mg_1	0.147	0.168	0.227	0.461	0.535	0.498	0.166	0.291	0.380
Mg_1-Mg_0	0.024***	0.026**	0.026**	0.095***	0.077***	0.068**	0.031***	0.053***	0.045
S.E.± (Difference)	0.0025	0.0065	0.0060	0.0115	0.0133	0.0171	0.0047	0.0092	0.0175

TABLE 8(b). EXPERIMENT I(i). SHARPLAW, 1960 Per cent Mg in DM.

EFFECT	GRASS			CLOVER			MIXED HERBAGE		
	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	0.083	0.100	0.157	0.497	0.466	0.370	0.115	0.255	0.306
N_1	0.132	0.114	0.146	0.412	0.589	0.471	0.138	0.157	0.326
N_1-N_0	0.049***	0.014	-0.011	-0.085	0.123*	0.101*	0.023*	-0.098**	0.020
K_0	0.112	0.115	0.148	0.464	0.569	0.464	0.125	0.197	0.328
K_1	0.103	0.099	0.155	0.445	0.486	0.376	0.128	0.215	0.304
K_1-K_0	-0.009	-0.016*	0.007	-0.019	-0.083*	-0.088*	0.003	0.018	-0.024
S.E.± (Difference)	0.0037	0.0052	0.0065	0.0376	0.0234	0.0259	0.0042	0.0088	0.0211
NK Interaction									
N_0K_0	0.089	0.108	0.146	0.502	0.522	0.431	0.109	0.234	0.330
N_1K_0	0.135	0.123	0.150	0.425	0.617	0.498	0.141	0.161	0.326
N_0K_1	0.077	0.092	0.168	0.492	0.409	0.308	0.121	0.277	0.283
N_1K_1	0.130	0.105	0.142	0.399	0.562	0.444	0.136	0.152	0.326
S.E.± (Difference)	0.0052	0.0073	0.0091	0.0531	0.0331	0.0366	0.0059	0.0125	0.0299
Mg_0	0.097	0.100	0.142	0.363	0.450	0.347	0.108	0.190	0.273
Mg_1	0.119	0.114	0.161	0.546	0.605	0.494	0.145	0.222	0.359
Mg_1Mg_0	0.022***	0.014***	0.019*	0.183***	0.155***	0.147***	0.037***	0.032*	0.086**
S.E.± (Difference)	0.0024	0.0022	0.0062	0.0138	0.0098	0.0265	0.0034	0.0076	0.0158

TABLE 9(a). EXPERIMENT I(i). KINGSIDE, 1960. Uptake of Mg (lb per acre).

EFFECT	GRASS				CLOVER				MIXED HERBAGE			
	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	1.2	1.4	0.8	3.4	0.4	5.9	4.1	10.4	1.6	7.3	4.8	13.7
N_1	5.6	2.2	0.8	8.6	0.3	1.1	1.6	3.0	5.9	3.3	2.4	11.6
N_1-N_0	4.4***	0.8*	0	5.2***	-0.1	-4.8***	-2.5*	-7.4***	4.3***	-4.0***	-2.4**	-2.1*
K_0	3.4	1.8	0.7	5.9	0.4	4.3	2.9	7.6	3.8	6.1	3.7	13.6
K_1	3.4	1.7	0.8	5.9	0.3	2.7	2.7	5.7	3.7	4.5	3.5	11.7
K_1-K_0	0	-0.1	0.1	0	-0.1	-1.6*	-0.2	1.9**	-0.1	-1.6**	-0.2	-1.9*
S.E.± (Difference)	0.21	0.16	0.04	0.29	0.08	0.28	0.43	0.19	0.17	0.24	0.42	0.41
NK Interaction												
N_0K_0	1.1	1.4	0.7	3.2	0.4	7.1	4.2	11.7*	1.6	8.5	4.9	15.0
N_1K_0	5.7	2.2	0.8	8.7	0.3	1.5	1.7	3.5	6.0	3.7	2.5	12.2
N_0K_1	1.3	1.4	0.9	3.6	0.3	4.7	4.0	9.0	1.6	6.1	4.8	12.5
N_1K_1	5.4	2.1	0.8	8.3	0.3	0.8	1.5	2.6	5.7	2.9	2.3	10.9
S.E.± (Difference)	0.30	0.23	0.06	0.40	0.12	0.39	0.61	0.27	0.24	0.34	0.60	0.59
Mg_0	3.2	1.7	0.7	5.6	0.3	3.1	2.6	6.0	3.4	4.8	3.2	11.4
Mg_1	3.6	1.9	0.9	6.4	0.4	4.0	3.1	7.5	4.0	5.8	4.0	13.8
Mg_1-Mg_0	0.4	0.2	0.2***	0.8	0.1	0.9*	0.5	1.5*	0.6	1.0*	0.8	2.4**
S.E.± (Difference)	0.26	0.11	0.04	0.32	0.09	0.26	0.38	0.52	0.25	0.34	0.40	0.59

TABLE 9(b). EXPERIMENT I (i). SHARPLAW, 1960. Uptake of Mg (lb per acre).

EFFECT	GRASS				CLOVER				MIXED HERBAGE			
	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	1.2	1.2	0.9	3.3	0.6	4.5	5.7	10.8	1.8	5.8	6.6	14.2
N_1	5.0	1.9	0.7	7.6	0.3	0.9	3.3	4.5	5.4	2.8	4.0	12.2
N_1-N_0	3.8***	0.7	-0.2	4.3**	-0.3	-3.6**	-2.4	-6.3*	3.6**	-3.0*	-2.6	-2.0
K_0	3.1	1.8	0.9	5.8	0.4	2.1	4.2	6.7	3.5	3.9	5.1	12.5
K_1	3.1	1.3	0.7	5.1	0.6	3.4	4.8	8.8	3.7	4.7	5.5	13.9
K_1-K_0	0	-0.5	-0.2	-0.7	0.2	1.3	0.6	2.1	0.2	0.8	0.4	1.4
S.E.± (Difference)	0.22	0.20	0.17	0.42	0.13	0.54	1.09	1.64	0.29	0.73	1.20	1.87
NK Interaction												
N_0K_0	1.2	1.6	1.0	3.8	0.4	3.3	5.1	8.8	1.6	4.9	6.1	12.6
N_1K_0	5.0	2.1	0.8	7.9	0.3	0.9	3.2	4.4	5.4	2.9	4.0	12.2
N_0K_1	1.1	0.9	0.7	2.7	0.9	5.8	6.3	13.0	2.0	6.7	7.0	15.7
N_1K_1	5.0	1.6	0.7	7.3	0.4	1.0	3.3	4.7	5.4	2.6	4.0	12.0
S.E.± (Difference)	0.31	0.28	0.23	0.59	0.18	0.76	1.53	2.31	0.40	1.04	1.69	2.64
Mg_0	2.6	1.3	0.7	4.6	0.3	2.4	3.9	6.6	3.0	3.7	4.6	11.3
Mg_1	3.5	1.8	0.9	6.2	0.6	3.1	5.1	8.8	4.2	4.8	6.0	15.0
Mg_1-Mg_0	0.9***	0.5**	0.2***	1.6***	0.3***	0.7*	1.2*	2.2***	1.2***	1.1**	1.4**	3.7***
S.E.± (Difference)	0.12	0.10	0.03	0.11	0.05	0.20	0.36	0.30	0.14	0.25	0.35	0.34

TABLE 10(a) EXPERIMENT I(1). KINGSIDE, 1960 - 1964. Yield of Dry Matter (cwt per acre).

	1960				1961				1962			
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	10.0	20.1	11.5	41.6	9.1	35.8	11.1	56.0	11.5	18.4	5.6	35.5
N_1	33.1	14.2	6.2	53.5	21.2	22.1	8.4	51.7	22.3	12.0	3.8	38.1
N_1-N_0	23.1***	-5.9*	-5.3**	11.9*	12.1***	-13.7**	-2.7	-4.3	10.8**	-6.4**	-1.8	2.6
K_0	21.1	17.6	8.4	47.1	13.5	28.8	9.2	51.5	13.4	14.9	3.8	32.1
K_1	22.0	16.7	9.3	48.0	16.7	29.1	10.3	56.1	20.3	15.5	5.6	41.4
K_1-K_0	0.9	-0.9	0.9	0.9	3.2*	0.3	1.1	4.6	6.9**	0.6	1.8	9.3*
S.E.± (Difference)	0.67	1.27	0.70	2.12	0.63	1.16	0.93	1.66	0.94	0.51	0.80	2.17
NK Interaction												
N_0K_0	9.4	20.5	10.8	40.7	7.3	35.7	10.3	53.3	8.9	17.4	4.6	30.9
N_1K_0	32.8	15.2	5.9	53.9	19.8	22.0	8.0	49.8	18.0	12.4	3.0	33.4
N_0K_1	10.7	19.7	12.3	42.7	10.8	36.0	11.8	58.6	14.2	19.4	6.7	40.3
N_1K_1	33.3	13.3	6.4	53.0	22.6	22.2	8.8	53.6	26.5	11.7	4.6	42.8
S.E.± (Difference)	0.94	1.79	0.99	3.00	0.89	1.64	1.31	2.34	1.33	0.72	1.13	3.07
Mg_0	21.7	17.2	8.3	47.2	15.3	29.6	9.8	54.7	17.4	15.5	4.9	37.8
Mg_1	21.4	17.0	9.4	47.8	15.0	28.4	9.7	53.1	16.4	14.9	4.6	35.9
Mg_1-Mg_0	-0.3	-0.2	1.1	0.6	-0.3	-1.2	-0.1	-1.6	-1.0	-0.6	-0.3	-1.9
S.E.± (Difference)	1.07	0.57	0.70	1.50	1.87	1.25	0.19	2.18	0.39	0.61	0.40	1.02

continued overleaf /

TABLE 10(a) continued. EXPERIMENT I(i). KINGSIDE, 1960-1964. Yield of Dry Matter (cwt per acre).

	1963				1964		
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Total
N_0	12.2	16.7	8.7	37.6	32.7	9.0	41.7
N_1	18.6	21.8	16.4	56.8	39.9	9.1	49.0
N_1-N_0	6.4*	5.1	7.7**	19.2**	7.2*	0.1	7.3**
K_0	14.0	18.1	11.0	43.1	32.5	8.1	40.6
K_1	16.9	20.3	14.1	51.3	40.1	10.1	50.2
K_1-K_0	2.9	2.2	3.1*	8.2	7.6*	2.0	9.6**
S.E.± (Difference)	1.82	1.99	0.60	3.17	1.75	1.07	1.17
NK Interaction							
N_0K_0	11.6	15.6	7.0	34.2	28.2	8.4	36.6
N_1K_0	16.3	20.8	14.9	52.0	36.7	7.7	44.4
N_0K_1	12.9	17.7	10.4	41.0	37.1	9.7	46.8
N_1K_1	21.0	22.9	17.9	61.8	43.0	10.6	53.6
S.E.± (Difference)	2.58	2.82	0.84	4.48	2.48	1.51	1.65
Mg_0	16.0	19.4	13.1	48.5	36.8	9.2	46.0
Mg_1	14.8	19.0	12.0	45.8	35.8	9.0	44.8
Mg_1-Mg_0	-1.2	-0.4	-1.1**	-2.7	-1.0	-0.2	-1.2
S.E.± (Difference)	1.05	0.68	0.27	1.11	1.68	0.83	2.07

TABLE 10(b). EXPERIMENT I(i). SHARPLAW, 1960 - 1964. Yield of Dry Matter (cwt per acre).

	1960				1961				1962			
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	13.6	19.8	19.8	33.2	22.6	25.7	15.5	63.8	22.9	16.1	10.2	49.2
N_1	34.5	15.9	10.8	61.2	32.3	19.1	9.2	60.6	36.6	9.6	6.7	52.9
N_1-N_0	20.9***	-3.9	-9.0	8.0	9.7**	-6.6	-6.3	-3.2	13.7**	-6.5*	-3.5	3.7
K_0	23.4	17.3	14.0	54.7	26.5	20.0	10.9	57.4	26.8	9.7	6.8	43.3
K_1	24.8	18.4	16.6	59.8	28.5	24.7	13.8	67.0	32.8	15.9	10.0	58.7
K_1-K_0	1.4	1.1	2.6	5.1	2.0	4.7	2.9	9.6	6.0*	6.2*	3.2	15.4*
S.E.± (Difference)	1.40	2.51	3.52	6.57	1.45	2.44	2.26	5.93	1.17	1.53	1.63	4.27
NK Interaction												
N_0K_0	12.8	18.3	17.4	48.5	21.8	21.2	12.9	55.9	20.2	11.4	7.9	39.5
N_1K_0	33.9	16.3	10.5	60.7	31.3	18.8	8.9	59.0	33.3	7.9	5.8	47.0
N_0K_1	14.5	21.4	22.2	58.1	23.5	30.1	18.1	71.7	25.6	20.7	12.5	58.8
N_1K_1	35.1	15.4	11.0	61.5	33.4	19.3	9.5	62.2	39.9	11.2	7.6	58.7
S.E.± (Difference)	1.98	3.55	4.98	9.29	2.05	3.45	3.20	8.39	1.66	2.16	2.30	6.03
Mg_0	23.3	16.9	15.3	55.5	27.2	22.5	12.4	62.1	29.8	12.5	8.4	50.7
Mg_1	24.8	18.8	15.2	58.8	27.7	22.2	12.3	62.2	29.7	13.2	8.5	51.4
Mg_1-Mg_0	1.5	1.9	-0.1	3.3	0.5	-0.3	-0.1	0.1	-0.1	0.7	0.1	0.7
S.E.± (Difference)	1.05	1.00	0.74	1.42	0.61	1.76	1.59	2.32	1.20	0.81	0.54	1.13

continued overleaf. /

TABLE 10(b) continued. EXPERIMENT I(i). SHARPLAW, 1960 - 1964. Yield of Dry Matter (Cwt per acre)

	1963				1964		
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Total
N_0	25.7	13.2	8.9	47.8	36.3	2.9	39.2
N_1	33.0	17.5	15.1	65.6	43.9	3.9	47.8
N_1-N_0	7.3*	4.3*	6.2*	17.8*	7.6*	1.0	8.6*
K_0	26.9	13.1	11.7	51.7	37.1	3.4	40.5
K_1	31.8	17.6	12.3	61.7	43.1	3.3	46.4
K_1-K_0	4.9*	4.5*	0.6	10.0	6.0*	-0.1	5.9*
S.E.± (Difference)	1.49	0.94	1.50	3.58	1.59	0.43	1.80
NK Interaction							
N_0K_0	23.8	11.3	8.6	43.7	33.8	2.9	36.7
N_1K_0	29.9	14.8	14.9	59.6	40.4	4.0	44.4
N_0K_1	27.5	15.2	9.2	51.9	38.9	2.9	41.8
N_1K_1	36.1	20.1	15.3	71.5	47.4	3.8	51.2
S.E.± (Difference)	2.11	1.33	2.13	5.06	2.25	0.60.	2.55
Mg_0	28.6	15.4	11.6	55.6	41.3	3.3	44.6
Mg_1	30.1	15.2	12.3	57.6	38.9	3.4	42.3
Mg_1-Mg_0	1.5	-0.2	0.7	2.0	-2.4	0.1	-2.3
S.E.± (Difference)	2.96	0.37	0.60	3.54	1.89	0.18	1.96

TABLE 10(c) EXPERIMENT I(i). GLENDEUGLIE, 1960 - 1964. Yield of Dry Matter (cwt per acre).

	1960				1961				1962			
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	17.5	7.9	9.4	34.8	11.4	22.9	13.0	47.3	15.6	9.3	8.5	33.4
N_1	38.4	7.0	8.0	53.4	22.4	21.2	9.2	52.8	23.7	9.7	6.4	39.8
N_1-N_0	20.9**	-0.9	-1.4**	18.6**	11.0***	-1.7	-3.8*	5.5*	8.1**	0.4	-2.1	6.4*
K_0	28.2	6.7	7.5	42.4	15.0	19.5	8.5	43.0	16.2	8.4	6.2	30.8
K_1	27.7	8.2	9.9	45.8	18.8	24.6	13.7	57.1	23.1	10.6	8.7	42.4
K_1-K_0	-0.5	1.5*	2.4***	3.4	3.8*	5.1*	5.2*	14.1***	6.9**	2.2	2.5*	11.6**
S.E.± (Difference)	2.46	0.47	0.12	2.80	0.77	0.99	0.94	1.52	0.84	0.86	0.68	1.79
NK Interaction			**									
N_0K_0	15.8	7.0	7.8	30.6	10.0	20.2	10.1	40.3	13.4	8.3	7.1	28.8
N_1K_0	40.5	6.5	7.2	54.2	20.0	18.8	7.0	45.8	19.0	8.6	5.3	32.9
N_0K_1	19.2	8.9	11.0	39.1	12.8	25.6	16.0	54.4	17.9	10.4	9.9	38.2
N_1K_1	36.3	7.6	8.8	52.7	24.7	23.6	11.5	59.8	28.4	10.7	7.6	46.7
S.E.± (Difference)	3.48	0.66	0.17	3.96	1.09	1.40	1.34	2.15	1.19	1.22	0.96	2.54
Mg_0	27.7	7.4	8.5	43.6	16.4	21.4	11.5	49.3	19.2	9.6	7.0	35.8
Mg_1	28.2	7.6	8.8	44.6	17.4	22.6	10.8	50.8	20.1	9.4	7.9	37.4
Mg_1-Mg_0	0.5	0.2	0.3	1.0	1.0**	1.2	-0.7	1.5	0.9	-0.2	0.9	1.6**
S.E.± (Difference)	2.11	0.48	0.49	1.84	0.23	0.88	0.77	1.60	0.43	0.33	0.41	0.33

continued overleaf /

TABLE 10(c) continued EXPERIMENT I(i). GLENDEUGLIE, 1960-1964. Yield of Dry Matter (cwt per acre).

	1963			1964			
EFFECT	Cut 1	Cut 2	Total	Cut 1	Cut 2	Cut 3	Total
N_0	19.3	14.5	33.8	9.4	25.1	3.4	37.9
N_1	26.2	13.2	39.4	18.1	23.3	3.5	44.9
N_1-N_0	6.9*	-1.3	5.6*	8.7**	-1.8	0.1	7.0
K_0	18.8	11.9	30.7	12.3	22.5	2.7	37.5
K_1	26.7	15.8	42.5	15.2	25.8	4.2	45.2
K_1-K_0	7.9*	3.9	11.8**	2.9	3.3	1.5*	7.7
S.E.± (Difference)	1.42	1.60	1.65	1.12	1.45	0.34	2.46
NK Interaction							
N_0K_0	15.7	12.5	28.2	8.2	22.5	2.5	33.2
N_1K_0	22.0	11.2	33.2	16.5	22.5	3.0	42.0
N_0K_1	22.9	16.5	39.4	10.6	27.6	4.3	42.5
N_1K_1	30.4	15.2	45.6	19.7	24.0	4.0	47.7
S.E.± (Difference)	2.01	2.26	2.33	1.58	2.05	0.48	3.47
Mg_0	23.0	14.1	37.1	14.1	24.6	3.3	42.0
Mg_1	22.5	13.5	36.0	13.4	23.8	3.6	40.8
Mg_1-Mg_0	-0.5	-0.6	-1.1	-0.7	-0.8	0.3	-1.2
S.E.± (Difference)	0.44	0.37	0.44	1.15	0.84	0.45	1.54

TABLE 11(a). EXPERIMENT I(i). KINGSIDE, 1960 - 1965. Per cent N in DM of Mixed Herbage.

	1960			1961			1962		
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	1.39	1.88	3.51	2.54	2.11	3.07	2.29	2.48	2.73
N_1	2.01	1.28	2.88	2.76	1.59	2.87	2.23	2.19	2.43
N_1-N_0	0.62**	-0.60**	-0.63**	0.22	-0.52**	-0.20	-0.06	-0.29**	-0.30*
K_0	1.71	1.60	3.24	2.68	1.89	3.00	2.32	2.30	2.56
K_1	1.70	1.56	3.15	2.62	1.82	2.94	2.21	2.36	2.61
K_1-K_0	-0.01	-0.04	-0.09	-0.06	-0.07	-0.06	-0.11	0.06	0.05
S.E.± (Difference)	0.048	0.060	0.049	0.099	0.066	0.073	0.097	0.045	0.094
NK Interaction									
N_0K_0	1.38	1.95	3.57	2.56	2.12	3.14	2.28	2.45	2.72
N_1K_0	2.04	1.25	2.91	2.81	1.65	2.86	2.35	2.15	2.40
N_0K_1	1.41	1.82	3.44	2.52	2.09	3.00	2.31	2.51	2.75
N_1K_1	1.98	1.30	2.86	2.71	1.54	2.88	2.11	2.22	2.46
S.E.± (Difference)	0.068	0.085	0.070	0.139	0.093	0.103	0.137	0.063	0.133
Mg_0	1.76	1.54	3.22	2.63	1.86	2.97	2.23	2.36	2.60
Mg_1	1.64	1.62	3.17	2.67	1.84	2.96	2.30	2.31	2.57
Mg_1-Mg_0	-0.12	0.08	-0.05	0.04	-0.02	-0.01	0.07	-0.05	-0.03
S.E.± (Difference)	0.059	0.054	0.086	0.097	0.037	0.026	0.042	0.054	0.072

continued overleaf /

TABLE 11(a) continued. EXPERIMENT I(i). Kingaside, 1960-1965. Per cent N in DM of Mixed Herbage.

	1963			1964		1965	
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 1	Cut 2
N_0	1.62	2.00	2.31	1.54	1.82	1.90	2.02
N_1	2.04	2.05	2.35	1.93	1.77	1.68	1.77
N_1-N_0	0.42**	0.05	0.04	0.39*	-0.05	-0.22*	-0.25*
K_0	1.89	2.02	2.33	1.80	1.84	1.82	1.85
K_1	1.78	2.03	2.32	1.68	1.75	1.75	1.94
K_1-K_0	-0.11	0.01	-0.01	-0.12	-0.09	-0.07	0.09
S.E.± (Difference)	0.065	0.114	0.072	0.095	0.078	0.045	0.070
NK Interaction							
N_0K_0	1.61	1.95	2.28	1.50	1.82	1.93	1.96
N_1K_0	2.16	2.10	2.39	2.09	1.86	1.72	1.73
N_0K_1	1.64	2.05	2.33	1.59	1.81	1.87	2.07
N_1K_1	1.92	2.01	2.31	1.78	1.69	1.63	1.82
S.E.± (Difference)	0.092	0.161	0.102	0.135	0.110	0.063	0.099
Mg_0	1.82	2.05	2.34	1.80	1.78	1.81	1.95
Mg_1	1.84	2.00	2.32	1.68	1.81	1.77	1.84
Mg_1-Mg_0	0.02	-0.05	-0.02	-0.12	0.03	-0.04	-0.11
S.E.± (Difference)	0.070	0.039	0.010	0.102	0.037	0.033	0.077

TABLE 11(b) EXPERIMENT I(i). SHARPLAW, 1960 - 1965. Per cent N in DM of Mixed Herbage.

EFFECT	1960 Cut 1	1960 Cut 2	1960 Cut 3	1961 Cut 1	1961 Cut 2	1961 Cut 3	1962 Cut 1	1962 Cut 2	1962 Cut 3
N_0	1.29	2.06	3.07	2.01	2.18	2.86	1.87	2.56	2.52
N_1	2.01	1.37	2.90	2.15	1.68	3.04	1.92	2.36	2.51
N_1-N_0	0.72***	-0.69**	-0.17	0.14*	-0.50**	0.18	0.05	-0.20*	-0.01
K_0	1.69	1.61	2.92	1.96	1.94	2.96	1.91	2.43	2.40
K_1	1.60	1.82	3.05	2.19	1.93	2.94	1.88	2.50	2.63
K_1-K_0	-0.09*	0.21	0.13	0.23**	-0.01	-0.02	-0.03	0.07	0.23*
S.E.± (Difference)	0.022	0.074	0.100	0.024	0.078	0.139	0.083	0.050	0.046
NK Interaction		*		* *			*		
N_0K_0	1.32	1.83	3.06	1.80	2.18	2.85	1.75	2.47	2.42
N_1K_0	2.06	1.39	2.79	2.13	1.69	3.06	2.08	2.39	2.39
N_0K_1	1.25	2.28	3.09	2.21	2.19	2.87	2.00	2.66	2.63
N_1K_1	1.96	1.35	3.01	2.16	1.68	3.01	1.76	2.34	2.63
S.E.± (Difference)	0.031	0.104	0.148	0.035	0.110	0.196	0.117	0.071	0.065
Mg_0	1.57	1.75	3.03	2.17	1.95	2.95	1.88	2.44	2.51
Mg_1	1.72	1.68	2.94	1.98	1.92	2.95	1.91	2.49	2.53
Mg_1-Mg_0	0.15*	-0.07	-0.09	-0.19	-0.03	0	0.03	0.05	0.02
S.E.± (Difference)	0.045	0.034	0.047	0.099	0.060	0.040	0.074	0.042	0.052

continued overleaf /

TABLE 11(b) continued. EXPERIMENT I(i). SHARPLAW, 1960 - 1965. Per cent N in DM of Mixed Herbage.

EFFECT	1963 Cut 1	1963 Cut 2	1963 Cut 3	1964 Cut 1	1964 Cut 2	1965 Cut 1	1965 Cut 2
N_0	1.42	1.77	2.22	1.20	2.33	1.54	2.19
N_1	1.66	1.83	2.14	1.62	2.35	1.39	2.07
N_1-N_0	0.24***	0.06	-0.08	0.42**	0.02	-0.15*	-0.12
K_0	1.57	1.82	2.21	1.49	2.43	1.47	2.12
K_1	1.51	1.78	2.15	1.33	2.26	1.46	2.14
K_1-K_0	-0.06	-0.04	-0.06	-0.16*	-0.17	-0.01	0.02
S.E.± (Difference)	0.017	0.037	0.044	0.033	0.064	0.037	0.061
NK Interaction							
N_0K_0	1.42	1.72*	2.21	1.25	2.39	1.54	2.16
N_1K_0	1.71	1.93	2.21	1.74	2.46	1.40	2.08
N_0K_1	1.42	1.82	2.23	1.16	2.26	1.55	2.22
N_1K_1	1.61	1.73	2.07	1.51	2.25	1.38	2.06
S.E.± (Difference)	0.025	0.052	0.063	0.047	0.090	0.052	0.086
Mg_0	1.54	1.82	2.23	1.39	2.37	1.46	2.15
Mg_1	1.54	1.78	2.13	1.43	2.31	1.47	2.11
Mg_1-Mg_0	0	-0.04	-0.10**	0.04	-0.06	0.01	-0.04
S.E.± (Difference)	0.022	0.033	0.023	0.025	0.056	0.032	0.075

TABLE 11(c). EXPERIMENT I(i). GLENDEUGLIE, 1960 - 1965 Per cent N in DM of Mixed Herbage.

	1960			1961			1962		
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	1.30	2.22	2.87	2.23	1.55	2.48	2.01	1.60	2.14
N_1	1.74	1.97	2.47	2.82	1.37	2.09	2.54	1.72	2.00
N_1-N_0	0.44**	-0.25*	-0.40*	0.59**	-0.18	-0.39*	0.53***	0.12	-0.14
K_0	1.58	2.04	2.57	2.58	1.43	2.24	2.36	1.71	2.09
K_1	1.46	2.14	2.77	2.47	1.50	2.33	2.19	1.61	2.06
K_1-K_0	-0.12	0.10	0.20	-0.11	0.07	0.09	-0.17*	-0.10	-0.03
S.E.± (Difference)	0.057	0.069	0.098	0.053	0.072	0.099	0.031	0.088	0.066
NK Interaction									
N_0K_0	1.32	2.07	2.72	2.22	1.46	2.47	2.06	1.61	2.13
N_1K_0	1.85	2.00	2.42	2.94	1.40	2.02	2.50	1.81	2.05
N_0K_1	1.28	2.36	3.02	2.24	1.64	2.49	1.97	1.59	2.15
N_1K_1	1.63	1.93	2.53	2.69	1.35	2.16	2.57	1.63	1.96
S.E.± (Difference)	0.081	0.097	0.139	0.075	0.102	0.140	0.044	0.124	0.094
Mg_0	1.48	2.07	2.65	2.52	1.45	2.30	2.28	1.66	2.08
Mg_1	1.55	2.11	2.69	2.53	1.48	2.27	2.27	1.65	2.07
Mg_1-Mg_0	0.07	0.04	0.04	0.01	0.03	-0.03	-0.01	-0.01	-0.01
S.E.± (Difference)	0.053	0.102	0.085	0.057	0.035	0.029	0.051	0.032	0.011

continued overleaf /

TABLE 11(c) continued EXPERIMENT I(i). GLENDEUGLIE, 1960-1965 Per cent N in DM of Mixed Herbage.

	1963		1964			1965	
EFFECT	Cut 1	Cut 2	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2
N_0	1.70	2.01	2.38	1.30	2.42	2.68	1.70
N_1	2.15	1.88	3.15	1.37	2.18	2.55	1.62
N_1-N_0	0.45**	-0.13	0.77**	0.07	-0.24*	-0.13	-0.08
K_0	2.05	1.95	2.88	1.38	2.24	2.64	1.57
K_1	1.80	1.95	2.65	1.29	2.36	2.58	1.75
K_1-K_0	-0.25*	0	-0.23*	-0.09	0.12	-0.06	0.18
S.E.± (Difference)	0.044	0.081	0.064	0.033	0.049	0.073	0.079
NK Interaction							
N_0K_0	1.79	1.94	2.42	1.30	2.27*	2.68	1.61
N_1K_0	2.32	1.95	3.34	1.46	2.22	2.61	1.53
N_0K_1	1.62	2.09	2.34	1.30	2.57	2.68	1.79
N_1K_1	1.98	1.82	2.97	1.28	2.14	2.49	1.71
S.E.± (Difference)	0.062	0.114	0.091	0.047	0.070	0.103	0.112
Mg_0	1.94	1.94	2.67	1.30	2.33	2.69	1.57
Mg_1	1.91	1.96	2.86	1.37	2.27	2.54	1.74
Mg_1-Mg_0	-0.03	0.02	0.19	0.07*	-0.06	-0.15	0.17***
S.E.± (Difference)	0.061	0.041	0.093	0.021	0.079	0.117	0.028

TABLE 12(a) EXPERIMENT I(i). KINGSIDE, 1960 - 1964. Uptake of N (lb per acre) by Mixed Herbage.

EFFECT	1960				1961				1962			
	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	15.6	42.5	45.3	103.4	25.9	84.6	37.9	148.4	29.6	51.0	17.3	97.9
N_1	74.6	20.1	19.9	114.6	65.7	39.4	27.0	132.1	55.1	29.4	10.5	95.0
N_1-N_0	59.0***	-22.4*	-25.4**	11.2	39.8**	-45.2**	-10.9	-16.3	25.5**	-21.6**	-6.8	-2.9
K_0	44.9	32.7	31.3	108.9	41.7	62.8	30.9	135.4	35.0	38.6	11.1	84.7
K_1	45.4	29.9	33.9	109.2	49.9	61.3	34.0	145.2	49.7	41.7	16.7	108.1
K_1-K_0	0.5	-2.8	2.6	0.3	8.2	-1.5	3.1	9.8	14.7*	3.1	5.6	23.4
S.E.± (Difference)	2.70	2.38	2.98	6.22	3.49	3.69	3.91	8.71	4.21	2.08	2.55	8.51
NK Interaction												
N_0K_0	14.4	44.7	43.3	102.4	21.0	85.0	36.1	142.1	22.6	47.6	13.9	84.1
N_1K_0	75.3	20.6	19.2	115.1	62.4	40.5	25.7	128.6	47.3	29.7	8.2	85.2
N_0K_1	16.8	40.2	47.2	104.2	30.7	84.2	39.8	154.7	36.5	54.3	20.7	111.5
N_1K_1	73.9	19.6	20.6	114.1	69.1	38.4	28.2	135.7	62.8	29.0	12.7	104.5
S.E.± (Difference)	3.82	3.36	4.21	8.80	4.93	5.22	5.53	12.31	5.95	2.94	3.60	12.03
Mg_0	47.9	30.6	31.2	109.7	45.8	63.6	32.5	141.9	42.8	41.4	14.5	98.7
Mg_1	42.4	31.9	34.0	108.3	45.8	60.4	32.4	138.6	41.8	38.9	13.3	94.0
Mg_1-Mg_0	-5.5	1.3	2.8	-1.4	0	-3.2	-0.1	-3.3	-1.0	-2.5	-1.2	-4.7
S.E.± (Difference)	4.47	1.60	2.83	4.81	7.04	2.65	0.54	8.28	1.29	2.09	1.14	3.42

continued overleaf /

TABLE 12(a) continued. EXPERIMENT I(1). KINGSIDE, 1960-1964. Uptake of N (lb per acre) by Mixed Herbage.

EFFECT	1963 Cut 1	1963 Cut 2	1963 Cut 3	1963 Total	1964 Cut 1	1964 Cut 2	1964 Total
N_0	22.2	37.2	22.5	81.9	56.9	18.4	75.3
N_1	42.4	49.9	43.2	135.5	85.4	17.9	103.0
N_1-N_0	20.2*	12.7*	20.7**	53.6**	28.5*	-0.5	28.0*
K_0	30.3	41.2	28.9	100.4	66.6	16.5	83.1
K_1	34.3	45.9	36.7	116.9	75.8	19.7	95.5
K_1-K_0	4.0	4.7	7.8	16.5	9.2	3.2	12.4
S.E. ± (Difference)	4.54	3.64	2.80	9.07	6.85	1.96	5.13
NK Interaction							
N_0K_0	20.9	33.9	17.8	72.6	47.7	17.1	64.8
N_1K_0	39.8	48.5	40.1	128.4	85.5	16.0	101.5
N_0K_1	23.6	40.6	27.2	91.4	66.2	19.6	85.8
N_1K_1	45.0	51.3	46.3	142.6	85.3	19.8	105.1
S.E.± (Difference)	6.42	5.15	3.96	12.83	9.69	2.77	7.25
Mg_0	33.3	44.6	34.6	112.5	74.3	18.2	92.5
Mg_1	31.3	42.6	31.1	105.0	68.1	18.1	86.2
Mg_1-Mg_0	-2.0	-2.0	-3.5**	-7.5*	-6.2	-0.1	-6.3
S.E.± (Difference)	2.58	1.81	0.77	2.52	4.29	1.67	5.74

TABLE 12(b). EXPERIMENT I(i). SHARPLAW, 1960 - 1964. Uptake of N (lb per acre) by Mixed Herbage.

EFFECT	1960 Cut 1	1960 Cut 2	1960 Cut 3	1960 Total	1961 Cut 1	1961 Cut 2	1961 Cut 3	1961 Total	1962 Cut 1	1962 Cut 2	1962 Cut 3	1962 Total
N_0	19.6	46.2	67.6	133.4	50.8	62.3	49.3	162.4	48.5	46.6	29.1	124.2
N_1	77.6	24.3	35.3	137.2	77.7	36.0	30.9	144.6	77.8	25.1	18.9	121.8
N_1-N_0	58.0***	-21.9*	-32.3	3.8	26.9**	-26.3**	-18.4*	-17.8	29.3**	-21.5*	-10.2	-2.4
K_0	48.7	31.5	46.2	126.4	59.1	43.5	35.2	137.8	58.3	26.3	18.4	103.0
K_1	48.6	39.0	56.7	144.3	69.5	54.8	45.0	169.3	68.0	45.4	29.6	143.0
K_1-K_0	-0.1	7.5	10.5	17.9	10.4*	11.3	9.8	31.5	9.7	19.1*	11.2	40.0*
S.E.± (Difference)	2.74	5.66	11.48	17.16	3.23	4.38	5.76	12.91	3.88	3.84	4.22	10.26
NK Interaction												
N_0K_0	18.9	37.9	58.9	115.7	43.5	51.2	40.5	135.2	39.5	31.6	21.5	92.6
N_1K_0	78.4	25.2	33.4	137.0	74.7	35.8	29.8	140.3	77.1	21.0	15.3	113.4
N_0K_1	20.3	54.5	76.3	151.1	58.2	73.5	58.0	189.7	57.4	61.5	36.7	155.6
N_1K_1	76.9	23.5	37.1	137.5	80.8	36.2	32.0	149.0	78.5	29.3	22.4	130.3
S.E.± (Difference)	3.88	8.00	16.23	24.27	4.56	6.20	8.14	18.26	5.49	5.43	5.96	14.50
Mg_0	44.6	34.3	52.3	131.2	66.5	49.3	40.5	156.3	62.8	34.5	23.9	121.2
Mg_1	52.7	36.2	50.6	139.5	62.0	49.0	39.7	150.7	63.5	37.2	24.1	124.8
Mg_1-Mg_0	8.1***	1.9	-1.7	8.3*	-4.5	-0.3	-0.8	-5.6	0.7	2.7	0.2	3.6
S.E.± (Difference)	0.76	2.09	3.11	2.92	2.04	3.03	4.30	5.00	2.93	1.83	1.82	4.68

continued overleaf /

TABLE 12(b) continued. EXPERIMENT I(i). SHARPLAW, 1960 - 1964. Uptake of N (lb. per acre) by Mixed Herbage.

	1963				1964		
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Total
N_0	40.7	26.2	21.9	88.8	48.6	7.5	56.1
N_1	61.2	35.5	36.1	132.8	79.3	10.2	89.5
N_1-N_0	20.5**	9.3*	14.2*	44.0*	30.7***	2.7	33.4***
K_0	47.5	26.7	28.8	103.0	62.8	9.3	72.1
K_1	54.4	35.0	29.1	118.5	65.1	8.4	73.5
K_1-K_0	6.9	8.3*	0.3	15.5	2.3	-0.9	1.4
S.E.± (Difference)	2.52	2.22	3.48	7.75	1.14	1.35	2.11
NK Interaction							
N_0K_0	37.8	21.5	20.8	80.1	47.1	7.7	54.8
N_1K_0	57.2	31.9	36.8	125.9	78.5	10.9	89.4
N_0K_1	43.7	30.9	22.9	97.5	50.1	7.3	57.4
N_1K_1	65.2	39.0	35.3	139.5	80.1	9.5	89.6
S.E.± (Difference)	3.56	3.13	4.92	10.96	1.62	1.91	2.98
Mg_0	49.8	31.3	29.0	110.1	64.5	8.9	73.4
Mg_1	52.1	30.3	29.0	111.4	63.4	8.8	72.2
Mg_1-Mg_0	2.3	-1.0	0	1.3	-1.1	-0.1	-1.2
S.E.±	5.66	0.83	1.34	6.98	3.14	0.33	3.15

TABLE 12(c) EXPERIMENT I(i). GLENDEUGLIE, 1960 - 1964. Uptake of N (lb per acre) of Mixed Herbage.

	1960				1961				1962			
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	25.5	19.8	30.4	75.7	28.4	40.1	36.1	104.6	35.0	16.7	20.3	72.0
N_1	75.2	15.5	22.3	113.0	70.3	32.4	21.7	124.4	66.8	18.4	14.3	99.5
N_1-N_0	49.7**	-4.3*	-8.1**	37.3*	41.9***	-7.7	-14.4**	19.8**	31.8***	1.7	-6.0*	27.5**
K_0	53.6	15.4	21.6	90.6	45.3	31.2	21.6	98.1	43.7	16.1	14.5	74.3
K_1	47.2	19.9	31.1	98.2	53.3	41.3	36.2	130.8	58.1	19.0	20.2	97.3
K_1-K_0	-6.4	4.5**	9.5**	7.6	8.0**	10.1*	14.6**	32.7***	14.4**	2.9	5.7*	23.0*
S.E.± (Difference)	6.64	0.75	0.79	7.53	1.18	2.61	1.63	2.25	2.24	1.01	1.40	4.10
NK Interaction		*										
N_0K_0	23.4	16.3	23.8	63.5	24.7	33.1	27.7	85.5	31.0	14.9	16.9	62.8
N_1K_0	83.8	14.5	19.5	117.8	66.0	29.3	15.6	110.9	56.4	17.3	12.1	85.8
N_0K_1	27.6	23.3	37.1	88.0	32.1	47.1	44.6	123.8	39.0	18.4	23.7	81.1
N_1K_1	66.7	16.4	25.0	108.1	74.5	35.4	27.9	137.8	77.2	19.5	16.6	113.3
S.E.± (Difference)	9.39	1.07	1.12	10.65	1.67	3.69	2.30	3.18	3.17	1.43	1.98	5.80
Mg_0	48.6	17.2	25.7	91.5	47.6	35.0	30.1	112.7	49.7	17.7	16.4	83.8
Mg_1	52.1	18.1	27.0	97.2	51.0	37.5	27.7	116.2	52.1	17.3	18.2	87.6
Mg_1-Mg_0	3.5	0.9	1.3	5.7	3.4	2.5	-2.4	3.5	2.4	-0.4	1.8	3.8
S.E.± (Difference)	5.35	1.69	1.97	6.00	1.27	2.00	1.78	3.33	1.45	0.77	0.91	1.81

continued overleaf /

TABLE 12(c) continued. EXPERIMENT I(i). GLENDEUGLIE, 1960-1964. Uptake of N (lb per acre) of Mixed Herbage.

	1963			1964			
EFFECT	Cut 1	Cut 2	Total	Cut 1	Cut 2	Cut 3	Total
N_0	36.4	32.6	69.0	25.0	36.5	9.3	70.8
N_1	62.1	27.7	89.8	63.5	35.5	8.5	107.5
N_1-N_0	25.7**	-4.9	20.8**	38.5**	-1.0	-0.8	36.7**
K_0	44.1	25.8	69.9	41.8	34.7	6.8	83.3
K_1	54.3	34.5	88.8	46.7	37.4	10.9	95.0
K_1-K_0	10.2*	8.7	18.8**	4.9	2.7	4.1*	11.7
S.E.± (Difference)	2.09	3.27	2.54	3.19	2.02	1.01	5.64
NK Interaction							
N_0K_0	31.3	27.1	58.4	22.1	32.6	6.3	61.0
N_1K_0	56.9	24.6	81.5	61.5	36.7	7.4	105.6
N_0K_1	41.5	38.1	79.6	27.8	40.3	12.3	80.4
N_1K_1	67.2	30.8	98.0	65.6	34.4	9.5	109.5
S.E.± (Difference)	2.95	4.62	3.59	4.51	2.86	1.43	7.98
Mg_0	50.2	30.6	80.8	43.1	35.7	8.5	87.3
Mg_1	48.3	29.7	78.0	45.4	36.4	9.2	91.0
Mg_1-Mg_0	-1.9	-0.9	-2.8	2.3	0.7	0.7	3.7
S.E.± (Difference)	1.04	1.18	1.94	4.26	1.12	0.95	4.75

TABLE 13(a). EXPERIMENT I(i). KINGSIDE, 1960 - 1965. Per cent P in DM of Mixed Herbage.

	1960[1].			1961			1962		
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	0.251	0.181	0.316	0.310	0.189	0.329	0.288	0.231	0.372
N_1	0.248	0.199	0.312	0.306	0.191	0.310	0.278	0.240	0.346
N_1-N_0	-0.003	0.018	-0.004	-0.004	0.002	-0.019	-0.010	0.009	-0.026
K_0	0.248	0.187	0.314	0.304	0.194	0.322	0.287	0.243	0.365
K_1	0.251	0.190	0.314	0.311	0.186	0.317	0.279	0.228	0.353
K_1-K_0	0.003	0.003	0	0.007	-0.008	-0.005	-0.008	-0.015	-0.012
S.E.± (Difference)				0.0201	0.0136	0.0226	0.0112	0.0095	0.0231
NK Interaction									
N_0K_0				0.303	0.192	0.325	0.284	0.240	0.379
N_1K_0				0.306	0.197	0.318	0.291	0.246	0.350
N_0K_1				0.316	0.185	0.332	0.293	0.222	0.365
N_1K_1				0.307	0.186	0.302	0.265	0.234	0.342
S.E.± (Difference)				0.0285	0.0193	0.0319	0.0158	0.0135	0.0327
Mg_0	0.255	0.186	0.312	0.304	0.190	0.318	0.280	0.236	0.361
Mg_1	0.244	0.191	0.316	0.312	0.190	0.321	0.286	0.236	0.357
Mg_1-Mg_0	-0.011	0.005	0.004	0.008	0	0.003	0.006	0	-0.004
S.E.± (Difference)				0.0138	0.0066	0.0029	0.0054	0.0056	0.0045

1. Not statistically analysed.

continued overleaf /

TABLE 13(a) continued. EXPERIMENT I(i). KINGSIDE, 1960 - 1965. Per cent P in DM of Mixed Herbage.

	1963			1964		1965	
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 1	Cut 2
N_0	0.304	0.320	0.373	0.263	0.313	0.289	0.299
N_1	0.319	0.326	0.348	0.271	0.286	0.268	0.276
N_1-N_0	0.015	0.006	-0.025	0.008	-0.027	-0.021	-0.023
K_0	0.316	0.331	0.368	0.276	0.310	0.284	0.288
K_1	0.307	0.315	0.352	0.258	0.289	0.273	0.288
K_1-K_0	-0.009	-0.016	-0.016	-0.018	-0.021	-0.011	0
S.E.± (Difference)	0.0089	0.0137	0.0123	0.0083	0.0145	0.0122	0.0161
NK Interaction							
N_0K_0	0.303	0.330	0.380	0.263	0.323	0.295	0.300
N_1K_0	0.329	0.332	0.357	0.290	0.298	0.273	0.275
N_0K_1	0.305	0.310	0.366	0.263	0.303	0.285	0.298
N_1K_1	0.309	0.321	0.339	0.253	0.275	0.263	0.278
S.E.± (Difference)	0.0126	0.0193	0.0174	0.0117	0.0207	0.0172	0.0228
Mg_0	0.308	0.317	0.355	0.261	0.294	0.274	0.283
Mg_1	0.314	0.330	0.366	0.273	0.305	0.283	0.293
Mg_1-Mg_0	0.006	0.013	0.011	0.012	0.011	0.009	0.010
S.E.± (Difference)	0.0102	0.0122	0.0203	0.0129	0.0048	0.0042	0.0064

TABLE 13(b) EXPERIMENT I(i). SHARPLAW, 1960 - 1965. Per cent P in DM of Mixed Herbage.

	1960[1].			1961			1962		
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	0.252	0.234	0.323	0.303	0.240	0.340	0.284	0.306	0.428
N_1	0.330	0.211	0.316	0.362	0.223	0.365	0.310	0.298	0.434
N_1-N_0	0.078	-0.023	-0.007	0.059***	-0.017	0.025*	0.026	-0.008	0.006
K_0	0.292	0.229	0.322	0.316	0.243	0.363	0.306	0.316	0.439
K_1	0.289	0.218	0.318	0.348	0.220	0.342	0.288	0.288	0.423
K_1-K_0	-0.003	-0.011	-0.004	0.032**	-0.023	-0.021*	-0.018	-0.028*	-0.016**
S.E.± (Difference)				0.0038	0.0072	0.0061	0.0062	0.0077	0.0028
NK Interaction									
N_0K_0				0.284	0.258	0.360	0.282*	0.316	0.441*
N_1K_0				0.348	0.228	0.367	0.330	0.315	0.438
N_0K_1				0.321	0.222	0.321	0.287	0.295	0.415
N_1K_1				0.375	0.219	0.363	0.289	0.282	0.430
S.E.± (Difference)				0.0053	0.0101	0.0086	0.0088	0.0109	0.0040
Mg_0	0.287	0.229	0.320	0.336	0.234	0.357	0.295	0.301	0.430
Mg_1	0.295	0.219	0.321	0.328	0.229	0.348	0.299	0.302	0.432
Mg_1-Mg_0	0.008	-0.010	0.001	-0.008	-0.005	-0.009	0.004	0.001	0.002
S.E.± (Difference)				0.0061	0.0032	0.0134	0.0048	0.0054	0.0048

1. Not statistically analysed.

continued overleaf /

TABLE 13(b) continued. EXPERIMENT I(i). SHARPLAW, 1960 - 1965. Per cent P in DM of Mixed Herbage.

	1963			1964		1965	
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 1	Cut 2
N_0	0.302	0.379	0.430	0.250	0.411	0.308	0.418
N_1	0.325	0.384	0.405	0.264	0.369	0.293	0.441
N_1-N_0	0.023**	0.005	-0.025*	0.014*	-0.042*	-0.015	0.023*
K_0	0.318	0.399	0.433	0.266	0.403	0.299	0.421
K_1	0.309	0.364	0.401	0.248	0.378	0.301	0.438
K_1-K_0	-0.009	-0.035*	-0.032	-0.018*	-0.025*	0.002	0.017
S.E.± (Difference)	0.0030	0.0074	0.0064	0.0043	0.0078	0.0074	0.0075
NK Interaction							
N_0K_0	0.307	0.399	0.449	0.255	0.428	0.310	0.420
N_1K_0	0.330	0.399	0.418	0.278	0.378	0.288	0.423
N_0K_1	0.297	0.359	0.412	0.245	0.395	0.305	0.415
N_1K_1	0.321	0.368	0.391	0.250	0.360	0.298	0.460
S.E.± (Difference)	0.0042	0.0104	0.0091	0.0060	0.0110	0.0104	0.0106
Mg_0	0.316	0.382	0.415	0.253	0.384	0.298	0.431
Mg_1	0.311	0.380	0.420	0.261	0.396	0.303	0.428
Mg_1-Mg_0	-0.005	-0.002	0.005	0.008	0.012	0.005	-0.003
S.E.± (Difference)	0.0063	0.0054	0.0046	0.0057	0.0110	0.0057	0.0052

TABLE 13(c). EXPERIMENT I(i). GLENDEUGLIE, 1960 - 1965. Per cent P in DM of Mixed Herbage.

EFFECT	1960			1961			1962		
	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	0.264	0.340	0.379	0.351	0.281	0.390	0.310	0.321	0.392
N_1	0.275	0.332	0.376	0.398	0.273	0.383	0.343	0.318	0.382
N_1-N_0	0.011	-0.008	-0.003	0.047*	-0.008*	-0.007	0.033*	-0.003	-0.010
K_0	0.276	0.342	0.382	0.375	0.281	0.404	0.340	0.335	0.399
K_1	0.263	0.330	0.374	0.374	0.274	0.369	0.312	0.304	0.375
K_1-K_0	-0.013	-0.012	-0.008	-0.001	-0.007*	-0.035	-0.028*	-0.031*	-0.024
S.E.± (Difference)	0.0060	0.0083	0.0171	0.0112	0.0021	0.0145	0.0078	0.0086	0.0221
NK Interaction									
N_0K_0	0.264	0.349	0.389	0.347	0.283	0.408	0.317	0.336	0.407
N_1K_0	0.287	0.336	0.375	0.404	0.278	0.399	0.363	0.333	0.391
N_0K_1	0.264	0.331	0.370	0.356	0.279	0.373	0.302	0.306	0.377
N_1K_1	0.263	0.328	0.378	0.392	0.268	0.366	0.322	0.303	0.373
S.E.± (Difference)	0.0085	0.0117	0.0242	0.0158	0.0030	0.0205	0.0110	0.0122	0.0313
Mg_0	0.268	0.333	0.376	0.373	0.273	0.386	0.325	0.314	0.385
Mg_1	0.271	0.339	0.380	0.376	0.281	0.387	0.327	0.325	0.389
Mg_1-Mg_0	0.003	0.006	0.004	0.003	0.008	0.001	0.002	0.011	0.004
S.E.± (Difference)	0.0077	0.0118	0.0064	0.0040	0.0112	0.0147	0.0086	0.0063	0.0091

continued overleaf /

TABLE 13(c) continued. EXPERIMENT I(i). GLENDEUGLIE, 1960-1965. Per cent P in DM of Mixed Herbage.

	1963		1964			1965	
EFFECT	Cut 1	Cut 2	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2
N_0	0.318	0.377	0.390	0.289	0.446	0.379	0.314
N_1	0.350	0.377	0.419	0.290	0.455	0.360	0.316
N_1-N_0	0.032	0	0.029*	0.001	0.009	−0.019	0.002
K_0	0.353	0.390	0.419	0.295	0.464	0.381	0.316
K_1	0.316	0.364	0.390	0.284	0.438	0.358	0.314
K_1-K_0	−0.037	−0.026	−0.029*	−0.011	−0.026	−0.023	−0.002
S.E.± (Difference)	0.0130	0.0139	0.0066	0.0105	0.0088	0.0177	0.0137
NK Interaction			*				
N_0K_0	0.329	0.387	0.390	0.290	0.460	0.388	0.310
N_1K_0	0.376	0.393	0.448	0.300	0.468	0.375	0.323
N_0K_1	0.308	0.368	0.390	0.288	0.433	0.370	0.318
N_1K_1	0.324	0.361	0.390	0.280	0.443	0.345	0.310
S.E.± (Difference)	0.0184	0.0197	0.0093	0.0148	0.0124	0.0251	0.0194
Mg_0	0.333	0.371	0.391	0.276	0.436	0.365	0.310
Mg_1	0.336	0.383	0.418	0.303	0.465	0.374	0.320
Mg_1-Mg_0	0.003	0.012	0.027*	0.027*	0.029	0.009	0.010
S.E.± (Difference)	0.0071	0.0066	0.0084	0.0094	0.0143	0.0138	0.0064

TABLE 14(a). EXPERIMENT I(i). KINGSIDE, 1960 - 1964. Uptake of P (lb per acre) by Mixed Herbage.

EFFECT	1960 Cut 1	1960 Cut 2	1960 Cut 3	1960 Total	1961 Cut 1	1961 Cut 2	1961 Cut 3	1961 Total	1962 Cut 1	1962 Cut 2	1962 Cut 3	1962 Total
N_0	2.8	4.1	4.1	11.0	3.3	7.5	4.1	14.9	3.7	4.7	2.3	10.7
N_1	9.2	3.2	2.2	14.6	7.3	4.7	2.9	14.9	6.9	3.2	1.5	11.6
N_1-N_0	6.4**	-0.9	-1.9**	3.6	4.0**	-2.8*	-1.2	0	3.2**	-1.5*	-0.8	0.9
K_0	5.9	3.7	2.9	12.5	4.7	6.3	3.4	14.4	4.4	4.0	1.6	10.0
K_1	6.1	3.6	3.3	13.0	5.9	6.0	3.7	15.6	6.3	3.9	2.3	12.5
K_1-K_0	0.2	-0.1	0.4	0.5	1.2	-0.3	0.3	1.2	1.9*	-0.1	0.7	2.5
S.E.± (Difference)	0.74	0.40	0.27	1.23	0.62	0.53	0.55	1.40	0.48	0.26	0.38	1.14
NK Interaction												
N_0K_0	2.6	4.2	3.9	10.7	2.6	7.7	3.8	14.1	2.8	4.7	1.9	9.4
N_1K_0	9.2	3.2	2.0	14.4	6.9	4.8	2.9	14.6	5.9	3.4	1.2	10.5
N_0K_1	3.0	4.0	4.3	11.3	4.0	7.4	4.4	15.8	4.6	4.8	2.7	12.1
N_1K_1	9.2	3.1	2.3	14.6	7.8	4.7	3.0	15.5	7.9	3.1	1.8	12.8
S.E.± (Difference)	1.04	0.56	0.38	1.74	0.87	0.75	0.77	1.98	0.68	0.37	0.54	1.61
Mg_0	6.2	3.6	2.9	12.7	5.2	6.3	3.5	15.0	5.3	4.1	2.0	11.4
Mg_1	5.8	3.7	3.3	12.8	5.4	6.0	3.5	14.9	5.3	3.9	1.9	11.1
Mg_1-Mg_0	-0.4	0.1	0.4	0.1	0.2	-0.3	0	-0.1	0	-0.2	-0.1	-0.3
S.E.± (Difference)	0.42	0.18	0.23	0.50	0.92	0.24	0.10	1.21	0.10	0.15	0.17	0.24

continued overleaf /

TABLE 14(a) continued. EXPERIMENT I(i). KINGSIDE, 1960-1964. Uptake of P (lb per acre) by Mixed Herbage.

	1963				1964		
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Total
N_0	4.2	5.9	3.6	13.7	9.6	3.2	12.8
N_1	6.7	7.9	6.4	21.0	12.0	2.9	14.9
N_1-N_0	2.5*	2.0*	2.8**	7.3*	2.4*	-0.3	2.1*
K_0	5.0	6.7	4.5	16.2	10.1	2.8	12.9
K_1	5.8	7.2	5.5	18.5	11.5	3.3	14.8
K_1-K_0	0.8	0.5	1.0	2.3	1.4	0.5	1.9*
S.E.± (Difference)	0.77	0.45	0.43	1.27	0.65	0.23	0.55
NK Interaction							
N_0K_0	3.9	5.8	3.0	12.7	8.3	3.0	11.3
N_1K_0	6.0	7.7	6.0	19.7	11.9	2.6	14.5
N_0K_1	4.4	6.1	4.3	14.8	10.9	3.3	14.2
N_1K_1	7.3	8.2	6.8	22.3	12.1	3.2	15.3
S.E.± (Difference)	1.09	0.64	0.60	1.79	0.92	0.32	0.77
Mg_0	5.6	6.8	5.1	17.5	10.7	3.0	13.7
Mg_1	5.3	7.0	4.9	17.2	11.0	3.0	14.0
Mg_1-Mg_0	-0.3	0.2	-0.2	-0.3	0.3	0	0.3
S.E.± (Difference)	0.52	0.32	0.43	0.97	0.54	0.28	0.78

TABLE 14(b) EXPERIMENT I(i). SHARPLAW, 1960 - 1964. Uptake of P (lb per acre) by Mixed Herbage.

	1960				1961				1962			
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	3.8	5.2	7.2	16.2	7.7	6.8	5.8	20.3	7.3	5.4	4.9	17.6
N_1	12.7	3.8	3.8	20.3	13.1	4.8	3.7	21.6	12.6	3.2	3.2	19.0
N_1-N_0	8.9***	-1.4	-3.4	4.1	5.4**	-2.0*	-2.1	1.3	5.3**	-2.2*	-1.7	1.4
K_0	8.1	4.4	5.1	17.6	9.6	5.4	4.4	19.4	9.4	3.4	3.4	16.2
K_1	8.5	4.5	5.9	18.9	11.2	6.1	5.2	22.5	10.6	5.2	4.7	20.5
K_1-K_0	0.4	0.1	0.8	1.3	1.6*	0.7	0.8	3.1	1.2	1.8*	1.3	4.3
S.E.± (Difference)	0.43	0.74	1.21	2.16	0.53	0.59	0.82	1.90	0.42	0.54	0.80	1.63
NK Interaction												
N_0K_0	3.6	4.9	6.4	14.9	6.9	6.1	5.1	18.1	6.4	4.0	3.9	14.3
N_1K_0	12.6	3.9	3.7	20.2	12.2	4.8	3.6	20.6	12.3	2.8	2.8	17.9
N_0K_1	4.1	5.4	7.9	17.4	8.5	7.5	6.5	22.5	8.2	6.8	5.8	20.8
N_1K_1	12.9	3.6	4.0	20.5	14.0	4.8	3.9	22.7	12.9	3.5	3.7	20.1
S.E.± (Difference)	0.61	1.05	1.71	3.05	0.75	0.83	1.17	2.69	0.59	0.76	1.13	2.31
Mg_0	7.9	4.3	5.5	17.7	10.5	5.9	4.9	21.3	9.9	4.2	4.0	18.1
Mg_1	8.7	4.6	5.5	18.8	10.4	5.7	4.7	20.8	10.0	4.4	4.1	18.5
Mg_1-Mg_0	0.8	0.3	0	1.1*	-0.1	-0.2	-0.2	-0.5	0.1	0.2	0.1	0.4
SE.± (Difference)	0.34	0.21	0.15	0.38	0.26	0.43	0.45	0.64	0.29	0.21	0.25	0.34

continued overleaf /

TABLE 14 (b) continued. EXPERIMENT I(i). SHARPLAW, 1960 - 1964. Uptake of P (lb per acre) by Mixed Herbage.

	1963				1964		
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Total
N_0	8.7	5.6	4.3	18.6	10.1	1.3	11.4
N_1	12.0	7.5	6.9	26.4	12.9	1.6	14.5
N_1-N_0	3.3**	1.9*	2.6*	7.8*	2.8*	0.3	3.1*
K_0	9.6	5.8	5.7	21.1	11.1	1.5	12.6
K_1	11.1	7.2	5.5	23.8	12.0	1.4	13.4
K_1-K_0	1.5	1.4	-0.2	2.7	0.9	-0.1	0.8
S.E.± (Difference)	0.46	0.49	0.79	1.58	0.48	0.20	0.57
NK Interaction							
N_0K_0	8.2	5.0	4.3	17.5	9.6	1.4	11.0
N_1K_0	11.1	6.6	7.0	24.7	12.5	1.7	14.2
N_0K_1	9.1	6.1	4.3	19.5	10.6	1.3	11.9
N_1K_1	13.0	8.3	6.7	28.0	13.3	1.5	14.8
S.E.± (Difference)	0.65	0.69	1.12	2.23	0.67	0.28	0.81
Mg_0	10.2	6.5	5.3	22.0	11.6	1.4	13.0
Mg_1	10.5	6.5	5.8	22.8	11.4	1.5	12.9
Mg_1-Mg_0	0.3	0	0.5	0.8	-0.2	0.1	-0.1
S.E.± (Difference)	1.24	0.09	0.24	1.48	0.41	0.05	0.42

TABLE 14(c). EXPERIMENT I(i). GLENDEUGLIE, 1960 - 1964. Uptake of P (lb per acre) by Mixed Herbage.

	1960				1961				1962			
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	5.2	3.0	4.0	12.2	4.5	7.2	5.7	17.4	5.4	3.4	3.7	12.5
N_1	11.9	2.6	3.4	17.9	10.0	6.4	3.9	20.3	9.0	3.4	2.7	15.1
N_1-N_0	6.7**	-0.4*	-0.6	5.7*	-5.5***	-0.8*	-1.8	2.9*	3.6**	0	-1.0	2.6*
K_0	8.9	2.6	3.2	14.7	6.5	6.1	3.9	16.5	6.2	3.2	2.8	12.2
K_1	8.2	3.0	4.2	15.4	8.0	7.5	5.7	21.2	8.1	3.6	3.7	15.4
K_1-K_0	-0.7	0.4*	1.0*	0.7	1.5*	1.4**	1.8	4.7**	1.9**	0.4	0.9	3.2*
S.E.± (Difference)	0.99	0.12	0.20	1.00	0.38	0.21	0.58	0.77	0.32	0.32	0.37	0.71
NK Interaction												
N_0K_0	4.7	2.8	3.4	10.9	3.9	6.4	4.7	15.0	4.8	3.1	3.3	11.2
N_1K_0	13.1	2.5	3.0	18.6	9.1	5.8	3.1	18.0	7.7	3.2	2.3	13.2
N_0K_1	5.7	3.3	4.6	13.6	5.1	8.0	6.7	19.8	6.0	3.6	4.2	13.8
N_1K_1	10.7	2.8	3.8	17.3	10.9	7.1	4.7	22.7	10.2	3.6	3.2	17.0
S.E.± (Difference)	1.39	0.18	0.28	1.41	0.54	0.30	0.82	1.09	0.46	0.45	0.52	1.01
Mg_0	8.4	2.7	3.6	14.7	7.0	6.5	4.9	18.4	7.0	3.4	3.0	13.4
Mg_1	8.7	2.9	3.8	15.4	7.5	7.1	4.7	19.3	7.4	3.4	3.4	14.2
Mg_1-Mg_0	0.3	0.2	0.2	0.7	0.5**	0.6	-0.2	0.9	0.4	0	0.4	0.8
S.E.± (Difference)	0.84	0.24	0.26	0.87	0.12	0.50	0.46	0.98	0.25	0.10	0.17	0.35

continued overleaf /

TABLE 14(c) continued. EXPERIMENT I(i). GLENDEUGLIE, 1960-1964. Uptake of P (lb per acre) by Mixed Herbage.

	1963			1964			
EFFECT	Cut 1	Cut 2	Total	Cut 1	Cut 2	Cut 3	Total
N_0	6.8	6.1	12.9	4.1	8.1	1.7	13.9
N_1	10.1	5.5	15.6	8.4	7.6	1.8	17.8
N_1-N_0	3.3*	-0.6	2.7*	4.3**	-0.5	0.1	3.9
K_0	7.5	5.2	12.7	5.9	7.4	1.4	14.7
K_1	9.5	6.4	15.9	6.6	8.2	2.0	16.8
K_1-K_0	2.0*	1.2	3.2*	0.7	0.8	0.6*	2.1
S.E.± (Difference)	0.61	0.57	0.79	0.52	0.61	0.18	1.22
NK Interaction							
N_0K_0	5.8	5.4	11.2	3.6	7.3	1.3	12.2
N_1K_0	9.2	4.9	14.1	8.3	7.6	1.6	17.5
N_0K_1	7.9	6.8	14.7	4.6	8.9	2.1	15.6
N_1K_1	11.1	6.1	17.2	8.6	7.5	2.0	18.1
S.E.± (Difference)	0.87	0.80	1.12	0.74	0.86	0.26	1.73
Mg_0	8.6	5.8	14.4	6.2	7.6	1.6	15.4
Mg_1	8.4	5.8	14.2	6.3	8.0	1.9	16.2
Mg_1-Mg_0	-0.2	0	-0.2	0.1	0.4	0.3	0.8
S.E.± (Difference)	0.21	0.16	0.25	0.45	0.28	0.20	0.34

TABLE 15(a). EXPERIMENT I(1). KINGSIDE, 1960 - 1965. Per cent K in DM of Mixed Herbage.

EFFECT	1960 Cut 1	1960 Cut 2	1960 Cut 3	1961 Cut 1	1961 Cut 2	1961 Cut 3	1962 Cut 1	1962 Cut 2	1962 Cut 3
N_0	2.14	1.42	2.50	2.28	1.02	1.52	1.59	1.20	1.88
N_1	2.54	1.14	2.30	2.28	0.89	1.26	1.39	1.03	1.64
N_1-N_0	0.40*	-0.28*	-0.20	0	-0.13*	-0.26*	-0.20	-0.17	-0.24
K_0	2.02	1.10	2.05	1.56	0.61	1.00	0.78	0.63	1.20
K_1	2.66	1.46	2.75	3.01	1.29	1.78	2.19	1.59	2.33
K_1-K_0	0.64**	0.36**	0.70*	1.45***	0.68***	0.78***	1.41***	0.96***	1.13**
S.E.± (Difference)	0.085	0.052	0.181	0.073	0.034	0.057	0.105	0.056	0.126
NK Interaction	*			*		*			
N_0K_0	1.99	1.21	2.07	1.72	0.63	1.02	0.88	0.65	1.33
N_1K_0	2.04	0.99	2.02	1.40	0.60	0.97	0.69	0.61	1.08
N_0K_1	2.28	1.63	2.92	2.84	1.40	2.03	2.30	1.74	2.44
N_1K_1	3.03	1.29	2.58	3.17	1.18	1.54	2.09	1.45	2.21
S.E.± (Difference)	0.120	0.073	0.256	0.104	0.048	0.081	0.148	0.079	0.179
Mg_0	2.36	1.25	2.40	2.27	0.97	1.42	1.49	1.14	1.77
Mg_1	2.31	1.31	2.40	2.30	0.94	1.37	1.48	1.08	1.75
Mg_1-Mg_0	-0.05	0.06	0	0.03	-0.03	-0.05	-0.01	-0.06	-0.02
S.E.± (Difference)	0.031	0.039	0.082	0.136	0.014	0.052	0.052	0.040	0.059

continued overleaf/

TABLE 15(a) continued. EXPERIMENT I(i). KINGSIDE, 1960-1965. Per cent K in DM of Mixed Herbage.

	1963			1964		1965	
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 1	Cut 2
N_0	1.83	2.00	2.10	1.69	1.53	1.53	1.29
N_1	1.67	1.82	1.67	1.50	1.03	1.18	1.07
N_1-N_0	-0.16*	-0.18	-0.43*	-0.19*	-0.50**	-0.35*	-0.22
K_0	1.06	1.14	1.17	0.98	0.92	1.13	1.00
K_1	2.44	2.68	2.59	2.22	1.64	1.59	1.36
K_1-K_0	1.38***	1.54***	1.42***	1.24***	0.72**	0.46**	0.36*
S.E.± (Difference)	0.030	0.096	0.087	0.058	0.059	0.066	0.097
NK Interaction							
N_0K_0	1.23*	1.29	1.38	1.06	1.02*	1.12*	1.00
N_1K_0	0.90	1.00	0.97	0.89	0.83	1.13	1.01
N_0K_1	2.44	2.71	2.81	2.32	2.04	1.94	1.57
N_1K_1	2.45	2.64	2.37	2.11	1.24	1.24	1.14
S.E.± (Difference)	0.042	0.135	0.123	0.082	0.083	0.093	0.138
Mg_0	1.73	1.94	1.85	1.62	1.29	1.32	1.19
Mg_1	1.77	1.88	1.91	1.57	1.27	1.39	1.17
Mg_1-Mg_0	0.04	-0.06	0.06	-0.05	-0.02	0.07	-0.02
S.E.± (Difference)	0.038	0.058	0.103	0.103	0.060	0.042	0.075

TABLE 15(b) EXPERIMENT I(i). SHARPLAW, 1960 - 1965. Per cent K in DM of Mixed Herbage.

EFFECT	1960 Cut 1	1960 Cut 2	1960 Cut 3	1961 Cut 1	1961 Cut 2	1961 Cut 3	1962 Cut 1	1962 Cut 2	1962 Cut 3
N_0	1.94	1.33	1.64	1.96	0.70	0.84	1.31	0.89	1.40
N_1	2.05	1.05	1.55	1.96	0.60	0.78	1.09	0.71	1.29
N_1-N_0	0.11	-0.28	-0.09	0	-0.10	-0.06	-0.22	-0.18	-0.11
K_0	1.69	1.07	1.50	1.37	0.54	0.79	0.71	0.54	1.12
K_1	2.30	1.31	1.68	2.55	0.76	0.83	1.68	1.06	1.58
K_1-K_0	0.61*	0.24	0.18	1.18**	0.22	0.04	0.97**	0.52*	0.46*
S.E.± (Difference)	0.187	0.174	0.099	0.127	0.083	0.112	0.081	0.088	0.111
NK Interaction									
N_0K_0	1.77	1.16	1.52	1.42	0.59	0.82	0.88	0.60	1.20
N_1K_0	1.61	0.99	1.48	1.31	0.50	0.76	0.55	0.49	1.04
N_0K_1	2.11	1.51	1.75	2.51	0.82	0.87	1.74	1.19	1.61
N_1K_1	2.50	1.10	1.61	2.60	0.70	0.80	1.63	0.92	1.54
S.E.± (Difference)	0.265	0.246	0.140	0.179	0.117	0.158	0.115	0.125	0.158
Mg_0	2.01	1.18	1.54	1.90	0.63	0.80	1.12	0.78	1.26
Mg_1	1.98	1.20	1.64	2.02	0.67	0.82	1.27	0.82	1.43
Mg_1-Mg_0	-0.03	0.02	0.10	0.12	0.04	0.02	0.15	0.04	0.17**
S.E.± (Difference)	0.061	0.032	0.055	0.075	0.043	0.029	0.083	0.041	0.047

continued overleaf /

TABLE 15(b) continued. EXPERIMENT I(i). SHARPLAW, 1960-1965. Per cent K in DM of Mixed Herbage.

	1963			1964		1965	
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 1	Cut 2
N_0	1.67	1.72	2.02	1.31	1.83	1.42	1.53
N_1	1.41	1.47	1.50	1.08	1.54	1.23	1.42
N_1-N_0	-0.26**	-0.25	-0.52**	-0.23*	-0.29*	-0.19*	-0.11
K_0	1.14	1.13	1.21	0.75	1.25	1.13	1.35
K_1	1.94	2.06	2.31	1.64	2.11	1.52	1.60
K_1-K_0	0.80***	0.93**	1.10***	0.89***	0.86**	0.39**	0.25
S.E.± (Difference)	0.032	0.085	0.057	0.065	0.087	0.055	0.086
NK Interaction	*						
N_0K_0	1.35	1.30	1.53	0.83	1.52	1.21	1.41
N_1K_0	0.93	0.96	0.89	0.67	0.99	1.06	1.27
N_0K_1	1.99	2.14	2.51	1.80	2.13	1.63	1.65
N_1K_1	1.89	1.98	2.11	1.49	2.09	1.41	1.55
S.E.± (Difference)	0.046	0.120	0.080	0.091	0.123	0.078	0.121
Mg_0	1.49	1.53	1.64	1.14	1.64	1.29	1.42
Mg_1	1.59	1.66	1.87	1.25	1.73	1.36	1.53
Mg_1-Mg_0	0.10	0.13	0.23**	0.11	0.09	0.07	0.11
S.E.± (Difference)	0.055	0.049	0.049	0.058	0.101	0.047	0.072

TABLE 15(c). EXPERIMENT I(i). GLENDEUGLIE, 1960 - 1965. Per cent K in DM of Mixed Herbage.

	1960			1961			1962		
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	2.20	2.06	2.68	2.34	1.52	1.77	1.81	1.50	1.83
N_1	1.89	1.74	2.23	1.94	1.08	1.14	1.34	1.05	1.20
N_1-N_0	-0.31*	-0.32**	-0.45***	-0.40	-0.44*	-0.63*	-0.47	-0.45	-0.63
K_0	1.76	1.68	2.23	1.48	0.84	1.04	0.84	0.72	0.99
K_1	2.32	2.12	2.68	2.80	1.76	1.87	2.32	1.83	2.04
K_1-K_0	0.56**	0.44**	0.45***	1.32**	0.92**	0.83**	1.48**	1.11**	1.05*
S.E.± (Difference)	0.058	0.051	0.022	0.189	0.110	0.122	0.161	0.144	0.233
NK Interaction									
N_0K_0	2.06*	1.87	2.51*	1.84	1.06	1.29	1.09	0.91	1.23
N_1K_0	1.47	1.48	1.96	1.11	0.62	0.80	0.59	0.54	0.76
N_0K_1	2.34	2.25	2.85	2.83	1.98	2.25	2.54	2.10	2.44
N_1K_1	2.31	1.99	2.51	2.77	1.54	1.48	2.10	1.57	1.64
S.E.± (Difference)	0.082	0.072	0.031	0.267	0.155	0.172	0.227	0.203	0.330
Mg_0	2.01	1.87	2.43	2.04	1.25	1.40	1.51	1.23	1.52
Mg_1	2.07	1.93	2.48	2.24	1.35	1.51	1.64	1.32	1.52
Mg_1-Mg_0	0.06	0.06	0.05	0.20**	0.10	0.11	0.13	0.09	0
S.E.± (Difference)	0.095	0.043	0.053	0.046	0.053	0.045	0.133	0.071	0.076

continued overleaf /

TABLE 15(c) continued. EXPERIMENT I(i). GLENDEUGLIE, 1960-1965. Per cent K in DM of Mixed Herbage.

	1963		1964			1965	
EFFECT	Cut 1	Cut 2	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2
N_0	2.04	1.71	1.82	1.15	1.72	1.67	1.05
N_1	1.58	1.23	1.40	0.90	1.34	1.30	0.84
N_1-N_0	-0.46	-0.48*	-0.42	-0.25	-0.38**	-0.37	-0.21
K_0	1.13	1.02	1.08	0.60	0.93	1.19	0.81
K_1	2.50	1.92	2.14	1.46	2.13	1.79	1.08
K_1-K_0	1.37**	0.90**	1.06**	0.86*	1.20***	0.60	0.27
S.E.± (Difference)	0.224	0.137	0.155	0.151	0.060	0.230	0.132
NK Interaction							
N_0K_0	1.39	1.17	1.24	0.70	1.06	1.29	0.88
N_1K_0	0.86	0.86	0.92	0.50	0.81	1.08	0.77
N_0K_1	2.70	2.25	2.41	1.61	2.39	2.05	1.22
N_1K_1	2.31	1.59	1.88	1.30	1.88	1.53	0.94
S.E.± (Difference)	0.317	0.194	0.219	0.214	0.085	0.325	0.187
Mg_0	1.73	1.46	1.59	1.07	1.50	1.49	0.97
Mg_1	1.89	1.48	1.63	0.99	1.56	1.49	0.92
Mg_1-Mg_0	0.16	0.02	0.04	-0.08	0.06	0	-0.05
S.E.± (Difference)	0.136	0.094	0.066	0.044	0.064	0.089	0.083

TABLE 16(a). EXPERIMENT I(i). KINGSIDE, 1960 - 1964. Uptake of K (lb per acre) by Mixed Herbage.

	1960				1961				1962			
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	24.0	31.7	32.5	88.2	25.0	40.9	19.3	85.2	22.5	25.2	12.6	60.3
N_1	94.0	18.1	15.9	128.0	56.0	22.0	12.0	90.0	38.0	13.5	7.5	59.0
N_1-N_0	70.0***	-13.6	-16.6***	39.8*	31.0**	-18.9***	-7.3*	4.8	15.5**	-11.7***	-5.1	-1.3
K_0	48.0	22.0	19.2	89.2	22.8	19.9	10.3	53.0	11.3	10.5	5.3	27.1
K_1	70.1	27.9	29.2	127.2	58.2	43.0	21.0	122.2	49.1	28.2	14.8	92.1
K_1-K_0	22.1*	5.9	10.0**	38.0*	35.4***	23.1***	10.7**	69.2***	37.8***	17.7***	9.5*	65.0***
S.E.± (Difference)	4.40	2.79	1.16	7.29	2.56	0.64	1.70	2.44	1.22	0.58	1.86	2.84
NK Interaction	*		*		*	***			**	**		
N_0K_0	20.9	27.5	25.1	73.5	14.4	25.2	11.8	51.4	8.6	12.7	6.8	28.1
N_1K_0	75.1	16.5	13.3	104.9	31.3	14.7	8.9	54.9	14.0	8.4	3.8	26.2
N_0K_1	27.2	36.0	39.8	103.0	35.7	56.6	26.9	119.2	36.3	37.8	18.3	92.4
N_1K_1	113.0	19.7	18.5	151.2	80.7	29.3	15.2	125.2	62.0	18.7	11.3	92.0
S.E.± (Difference)	6.23	3.94	1.64	10.31	3.62	0.90	2.40	3.45	1.73	0.81	2.63	4.01
Mg_0	61.1	24.6	22.8	108.5	39.5	33.1	15.9	88.5	31.1	21.2	10.6	62.9
Mg_1	57.0	25.2	25.6	107.8	41.5	29.8	15.5	86.8	29.3	17.5	9.5	56.3
Mg_1-Mg_0	-4.1	0.6	2.8	-0.7	2.0	-3.3	-0.4	-1.7	-1.8	-3.7*	-1.1	-6.6
S.E.± (Difference)	2.00	1.00	1.39	2.91	8.63	1.85	0.96	9.45	1.60	1.09	0.92	2.41

continued overleaf /

TABLE 16(a) continued. EXPERIMENT I(i). KINGSIDE, 1960-1964 Uptake of K (lb per acre) by Mixed Herbage.

EFFECT	1963 Cut 1	Cut 2	Cut 3	Total	1964 Cut 1	Cut 2	Total
N_0	25.4	37.9	21.7	85.0	64.8	15.8	80.6
N_1	36.9	45.4	31.8	114.1	69.3	10.8	80.1
N_1-N_0	11.5	7.5	10.1***	29.1*	4.5	-5.0*	-0.5
K_0	16.1	22.8	13.5	52.4	35.2	8.3	43.5
K_1	46.2	60.5	40.0	146.7	99.0	18.3	117.3
K_1-K_0	30.1**	37.7**	26.5***	94.3**	63.8***	10.0**	73.8***
S.E.± (Difference)	4.56	3.47	0.75	7.82	3.78	1.11	2.86
NK Interaction			**				
N_0K_0	15.9	22.5	10.8	49.2	33.2	9.7	42.9
N_1K_0	16.3	23.1	16.1	55.5	37.1	7.0	44.1
N_0K_1	34.9	53.3	32.6	120.8	96.4	21.9	118.3
N_1K_1	57.4	67.7	47.5	172.6	101.5	14.6	116.1
S.E.± (Difference)	6.45	4.91	1.05	11.06	5.35	1.57	4.04
Mg_0	32.4	43.2	28.1	103.7	70.0	13.4	83.4
Mg_1	29.9	40.1	25.4	95.4	64.1	13.2	77.3
Mg_1-Mg_0	-2.5	-3.1	-2.7	-8.3	-5.9	-0.2	-6.1
S.E.± (Difference)	2.83	1.84	2.16	4.26	5.25	1.24	6.10

TABLE 16 (b). EXPERIMENT I(i). SHARPLAW, 1960 - 1964. Uptake of K (lb per acre) by Mixed Herbage.

EFFECT	1960 Cut 1	1960 Cut 2	1960 Cut 3	1960 Total	1961 Cut 1	1961 Cut 2	1961 Cut 3	1961 Total	1962 Cut 1	1962 Cut 2	1962 Cut 3	1962 Total
N_0	29.8	30.5	37.2	97.5	50.7	20.8	15.0	86.5	34.8	17.8	16.9	69.5
N_1	79.4	18.8	18.6	116.8	71.6	12.9	8.1	92.6	46.5	8.1	9.9	64.5
N_1-N_0	49.6**	-11.7	-18.6	19.3	20.9*	-7.9	-6.9	6.1	11.7*	-9.7*	-7.0	-5.0
K_0	43.1	21.7	24.3	89.1	40.6	12.4	10.1	63.1	20.2	6.1	8.9	35.2
K_1	66.2	27.6	31.6	125.4	81.7	21.3	13.1	116.1	61.1	19.7	17.8	98.6
K_1-K_0	23.1*	5.9	7.3	36.3	41.1**	8.9	3.0	53.0*	40.9**	13.6*	8.9	63.4**
S.E.± (Difference)	6.45	6.48	7.67	20.33	5.81	3.27	3.45	12.22	3.18	2.68	3.36	8.81
NK Interaction												
N_0K_0	25.5	24.8	31.1	81.4	35.4	14.2	12.4	62.0	20.0*	7.8	11.2	39.0
N_1K_0	60.7	18.6	17.4	96.7	45.8	10.6	7.7	64.1	20.4	4.5	6.7	31.6
N_0K_1	34.2	36.2	43.4	113.8	66.0	27.4	17.6	111.0	49.6	27.9	22.6	100.1
N_1K_1	98.1	19.0	19.9	137.0	97.4	15.3	8.5	121.2	72.6	11.6	13.1	97.3
S.E.± (Difference)	9.12	9.17	10.85	28.75	8.22	4.62	4.89	17.29	4.50	3.78	4.75	12.46
Mg_0	53.3	23.0	26.9	103.2	59.1	16.4	11.4	86.9	38.7	11.8	12.2	62.7
Mg_1	55.9	26.2	29.0	111.1	63.2	17.3	11.7	92.2	42.6	14.1	14.6	71.3
Mg_1-Mg_0	2.6	3.2	2.1	7.9	4.1	0.9	0.3	5.3	3.9*	2.3	2.4	8.6
S.E. ± (Difference)	2.94	1.30	1.77	4.50	3.06	1.67	1.93	5.68	1.27	1.53	1.25	3.60

continued overleaf /

TABLE 16(b)contd. EXPERIMENT I(i). SHARPLAW, 1960 - 1964. Uptake of K (lb per acre) by Mixed Herbage.

	1963				1964		
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Total
N_0	48.7	26.4	20.2	95.3	54.5	5.8	60.3
N_1	53.8	30.3	25.6	109.7	54.6	6.6	61.2
N_1-N_0	5.1	3.9	5.4	14.4	0.1	0.8	0.9
K_0	33.5	16.2	14.7	64.4	30.7	4.5	35.2
K_1	69.0	40.5	31.0	140.5	78.3	7.9	86.2
K_1-K_0	35.5**	24.3***	16.3**	76.1**	47.6***	3.4**	51.0***
S.E.± (Difference)	3.09	1.59	2.23	6.77	3.57	0.47	3.54
NK Interaction							
N_0K_0	35.9*	16.3	14.5	66.7	31.4	4.7	36.1
N_1K_0	31.1	16.0	14.9	62.0	30.1	4.4	34.5
N_0K_1	61.5	36.4	25.8	123.7	77.6	6.9	84.5
N_1K_1	76.5	44.5	36.2	157.2	79.1	8.8	87.9
S.E.± (Difference)	4.37	2.25	3.15	9.57	5.04	0.67	5.01
Mg_0	48.6	27.7	20.7	97.0	53.9	5.9	59.8
Mg_1	53.9	28.9	25.1	107.9	55.2	6.5	61.7
Mg_1-Mg_0	5.3	1.2	4.4	10.9	1.3	0.6	1.9
S.E.± (Difference)	7.12	1.32	1.70	9.40	2.47	0.34	2.79

TABLE 16(c). EXPERIMENT I(i). GLENDEUGLIE, 1960 - 1964. Uptake of K (lb per acre) by Mixed Herbage.

	1960				1961				1962			
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	43.5	18.5	28.4	90.4	30.5	40.4	27.3	98.2	33.5	16.3	18.1	67.9
N_1	80.3	14.0	20.3	114.6	50.9	26.7	12.8	90.4	39.6	12.0	9.2	60.8
N_1-N_0	36.8*	-4.5*	-8.1***	24.2	20.4*	-13.7*	-14.5**	-7.8	6.1	-4.3	-8.9*	-7.1
K_0	51.7	12.8	18.8	83.3	22.7	18.5	10.3	51.5	14.4	6.6	7.0	28.0
K_1	72.1	19.6	30.0	121.7	58.7	48.6	29.7	137.0	58.8	21.6	20.3	100.7
K_1-K_0	20.4	6.8**	11.2***	38.4*	36.0**	30.1**	19.4**	85.5***	44.4**	15.0**	13.3*	72.7**
S.E.± (Difference)	7.71	1.02	0.56	8.20	3.86	2.57	1.67	5.88	4.44	1.76	2.39	7.94
NK Interaction												
N_0K_0	36.7	14.6	21.8*	73.1	20.5*	24.0	14.3*	58.8	16.2	8.2	9.5	33.9
N_1K_0	66.8	11.0	15.7	93.5	25.0	13.0	6.4	44.4	12.6	5.1	4.5	22.2
N_0K_1	50.4	22.4	35.1	107.9	40.6	56.8	40.3	137.7	50.9	24.4	26.8	102.1
N_1K_1	93.8	16.9	24.9	135.6	76.8	40.4	19.2	136.4	66.7	18.8	13.9	99.4
S.E.± (Difference)	10.90	1.45	0.80	11.59	5.46	3.64	2.37	8.31	6.28	2.49	3.38	11.23
Mg_0	60.8	15.6	23.7	100.1	37.8	31.1	19.5	88.4	34.1	13.6	12.6	60.3
Mg_1	63.0	16.9	25.1	105.0	43.6	36.0	20.6	100.2	39.0	14.7	14.7	68.4
Mg_1-Mg_0	2.2	1.3	1.4	4.9	5.8***	4.9	1.1	11.8*	4.9	1.1	2.1	8.1*
S.E.± (Difference)	3.78	0.86	1.46	2.33	0.92	2.47	1.64	3.47	2.08	0.90	0.85	2.88

continued overleaf /

TABLE 16(c) continued EXPERIMENT I(i) GLENDEUGLIE, 1960-1964 Uptake of K (lb per acre) by Mixed Herbage.

	1963			1964			
EFFECT	Cut 1	Cut 2	Total	Cut 1	Cut 2	Cut 3	Total
N_0	47.1	28.4	75.5	19.9	33.7	7.2	60.8
N_1	49.8	19.0	68.8	29.0	23.7	5.5	58.2
N_1-N_0	2.7	-9.4*	-6.7	9.1*	-10.0	-1.7	-2.6
K_0	23.2	13.4	36.6	14.1	14.9	2.8	31.8
K_1	73.7	34.0	107.7	34.8	42.6	10.0	87.4
K_1-K_0	50.5**	20.6**	71.1**	20.7**	27.7*	7.2**	55.6**
S.E.± (Difference)	6.40	1.88	7.14	1.64	5.20	0.68	6.26
NK Interaction							
N_0K_0	25.2	15.7	40.9	11.4	17.4	2.9	31.7
N_1K_0	21.2	11.0	32.2	16.8	12.4	2.7	31.9
N_0K_1	69.0	41.0	110.0	28.4	50.1	11.6	90.1
N_1K_1	78.3	27.0	105.3	41.2	35.1	8.4	84.7
S.E.± (Difference)	9.04	2.65	10.09	2.32	7.35	0.97	8.85
Mg_0	47.1	23.5	70.6	25.1	30.5	5.7	61.3
Mg_1	49.8	23.9	73.7	23.8	27.0	7.0	57.8
Mg_1-Mg_0	2.7	0.4	3.1	-1.3	-3.5*	1.3	-3.5
S.E.± (Difference)	2.39	1.77	3.83	1.94	1.07	1.06	3.10

TABLE 17(a). EXPERIMENT I(1). KINGSIDE, 1960 - 1965. Per cent Mg in DM of Mixed Herbage.

EFFECT	1960			1961			1962		
	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	0.142	0.322	0.375	0.149	0.308	0.343	0.178	0.330	0.263
N_1	0.158	0.207	0.340	0.143	0.230	0.348	0.173	0.277	0.255
N_1-N_0	0.016**	-0.115**	-0.035	-0.006	-0.078**	0.005	-0.005	-0.053*	-0.008
K_0	0.157	0.298	0.385	0.159	0.295	0.370	0.186	0.325	0.280
K_1	0.144	0.231	0.330	0.133	0.243	0.321	0.164	0.282	0.239
K_1-K_0	-0.013*	-0.067*	-0.055*	-0.026**	-0.052*	-0.049**	-0.022*	-0.043*	-0.041**
S.E.± (Difference)	0.0023	0.0173	0.0169	0.0024	0.0100	0.0052	0.0042	0.0110	0.0051
NK Interaction									
N_0K_0	0.149	0.368	0.400	0.162	0.338	0.379*	0.179*	0.356	0.282
N_1K_0	0.164	0.228	0.370	0.156	0.253	0.361	0.193	0.295	0.278
N_0K_1	0.136	0.276	0.350	0.136	0.279	0.307	0.176	0.304	0.245
N_1K_1	0.152	0.187	0.310	0.131	0.207	0.334	0.152	0.260	0.232
S.E.± (Difference)	0.0032	0.0244	0.0239	0.0033	0.0142	0.0073	0.0059	0.0155	0.0072
Mg_0	0.135	0.238	0.335	0.124	0.244	0.311	0.156	0.275	0.235
Mg_1	0.166	0.291	0.380	0.169	0.295	0.380	0.194	0.332	0.284
Mg_1-Mg_0	0.031***	0.053***	0.045	0.045***	0.051**	0.069***	0.038***	0.057***	0.049***
S.E.± (Difference)	0.0047	0.0092	0.0175	0.0042	0.0096	0.0080	0.0018	0.0097	0.0052

continued overleaf /

TABLE 17(a) continued EXPERIMENT I(i). KINGSIDE, 1960-1965. Per cent Mg in DM of Mixed Herbage.

	1963			1964		1965	
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 1	Cut 2
N_0	0.145	0.260	0.228	0.174	0.249	0.193	0.240
N_1	0.166	0.221	0.226	0.203	0.281	0.195	0.248
N_1-N_0	0.021*	-0.039*	-0.002	0.029*	0.032*	0.002	0.008
K_0	0.175	0.260	0.254	0.200	0.289	0.198	0.258
K_1	0.137	0.222	0.200	0.176	0.241	0.190	0.230
K_1-K_0	-0.038*	-0.038*	-0.054**	-0.024*	-0.048*	-0.008	-0.028
S.E.± (Difference)	0.0066	0.0071	0.0079	0.0063	0.0089	0.0071	0.0111
NK Interaction							
N_0K_0	0.161	0.276	0.255	0.183	0.270	0.195	0.258
N_1K_0	0.188	0.243	0.253	0.218	0.308	0.200	0.258
N_0K_1	0.129	0.244	0.201	0.165	0.228	0.190	0.223
N_1K_1	0.145	0.199	0.199	0.188	0.255	0.190	0.238
S.E.± (Difference)	0.0094	0.0100	0.0112	0.0088	0.0126	0.0100	0.0157
Mg_0	0.139	0.218	0.206	0.178	0.249	0.181	0.233
Mg_1	0.172	0.263	0.248	0.199	0.281	0.206	0.255
Mg_1-Mg_0	0.033**	0.045**	0.042**	0.021**	0.032***	0.025***	0.022
S.E.± (Difference)	0.0076	0.0087	0.0093	0.0048	0.0031	0.0043	0.0083

TABLE 17(b) EXPERIMENT I(i). SHARPLAW, 1960 - 1965. Per cent Mg in DM of Mixed Herbage.

	1960			1961			1962		
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	0.115	0.255	0.306	0.163	0.283	0.387	0.157	0.273	0.272
N_1	0.138	0.157	0.326	0.138	0.230	0.417	0.141	0.258	0.299
N_1-N_0	0.023*	-0.098**	0.020	-0.025***	-0.053	0.030	-0.016	-0.015	0.027*
K_0	0.125	0.197	0.328	0.146	0.261	0.410	0.154	0.281	0.299
K_1	0.128	0.215	0.304	0.155	0.253	0.393	0.144	0.251	0.272
K_1-K_0	0.003	0.018	-0.024	0.009*	-0.008	-0.017	-0.010	-0.030*	-0.027*
S.E.± (Difference)	0.0042	0.0088	0.0211	0.0017	0.0186	0.0197	0.0052	0.0080	0.0077
NK Interaction									
N_0K_0	0.109	0.234	0.330	0.147***	0.288	0.397	0.146**	0.284	0.288
N_1K_0	0.141	0.161	0.326	0.145	0.233	0.424	0.161	0.279	0.311
N_0K_1	0.121	0.277	0.283	0.179	0.279	0.378	0.168	0.263	0.256
N_1K_1	0.136	0.152	0.326	0.131	0.277	0.409	0.120	0.238	0.288
S.E.± (Difference)	0.0059	0.0125	0.0299	0.0025	0.0263	0.0279	0.0073	0.0113	0.0108
Mg_0	0.108	0.190	0.273	0.122	0.201	0.337	0.123	0.217	0.241
Mg_1	0.145	0.222	0.359	0.179	0.312	0.467	0.175	0.315	0.330
Mg_1-Mg_0	0.037***	0.032*	0.086**	0.057***	0.111***	0.130***	0.052***	0.098***	0.089***
S.E.± (Difference)	0.0034	0.0076	0.0158	0.0100	0.0161	0.0081	0.0056	0.0085	0.0039

continued overleaf/

TABLE 17(b) continued. EXPERIMENT I(i). SHARPLAW, 1960 - 1965. Per cent Mg in DM of Mixed Herbage.

	1963			1964		1965	
EFFECT	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 1	Cut 2
N_0	0.116	0.223	0.219	0.138	0.259	0.155	0.243
N_1	0.136	0.226	0.236	0.175	0.280	0.146	0.241
N_1-N_0	0.020*	0.003	0.017	0.037**	0.021	-0.009	-0.002
K_0	0.139	0.238	0.243	0.170	0.288	0.160	0.245
K_1	0.114	0.210	0.212	0.143	0.251	0.141	0.239
K_1-K_0	-0.025*	-0.028*	-0.031	-0.027**	-0.037	-0.019	-0.006
S.E.± (Difference)	0.0061	0.0080	0.0127	0.0041	0.0114	0.0066	0.0114
NK Interaction							
N_0K_0	0.125	0.232	0.233	0.150	0.278	0.163	0.243
N_1K_0	0.152	0.245	0.254	0.190	0.298	0.158	0.248
N_0K_1	0.108	0.214	0.205	0.125	0.240	0.148	0.243
N_1K_1	0.120	0.207	0.219	0.160	0.263	0.135	0.235
S.E.± (Difference	0.0086	0.0113	0.0180	0.0058	0.0162	0.0093	0.0162
Mg_0	0.109	0.200	0.206	0.145	0.246	0.144	0.225
Mg_1	0.144	0.248	0.249	0.168	0.293	0.158	0.259
Mg_1-Mg_0	0.035***	0.048**	0.043***	0.023***	0.047***	0.014*	0.034*
S.E.± (Difference)	0.0036	0.0102	0.0019	0.0035	0.0082	0.0042	0.0078

TABLE 17(c) EXPERIMENT I(i). GLENDEUGLIE, 1960 - 1965. Per cent Mg in DM of Mixed Herbage.

EFFECT	1960			1961			1962		
	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2	Cut 3
N_0	0.119	0.248	0.273	0.146	0.175	0.289	0.147	0.195	0.259
N_1	0.147	0.243	0.277	0.165	0.177	0.320	0.166	0.229	0.297
N_1-N_0	0.028**	-0.005	0.004	0.019	0.002	0.031	0.019*	0.034*	0.038*
K_0	0.141	0.260	0.284	0.169	0.194	0.333	0.170	0.241	0.318
K_1	0.124	0.231	0.267	0.142	0.159	0.275	0.142	0.183	0.238
K_1-K_0	-0.017*	-0.029	-0.017	-0.027	-0.035	-0.058*	-0.028**	-0.058*	-0.080**
S.E.± (Difference)	0.0032	0.0194	0.0179	0.0094	0.0138	0.0126	0.0047	0.0103	0.0097
NK Interaction *									
N_0K_0	0.121	0.264	0.269	0.155	0.184	0.316	0.159	0.219	0.298
N_1K_0	0.162	0.256	0.299	0.183	0.204	0.349	0.182	0.263	0.338
N_0K_1	0.117	0.231	0.277	0.137	0.166	0.261	0.135	0.170	0.220
N_1K_1	0.132	0.230	0.256	0.148	0.151	0.290	0.150	0.195	0.257
S.E.± (Difference)	0.0045	0.0274	0.0253	0.0133	0.0195	0.0178	0.0066	0.0146	0.0137
Mg_0	0.119	0.228	0.252	0.137	0.151	0.270	0.137	0.186	0.237
Mg_1	0.147	0.262	0.298	0.174	0.201	0.339	0.175	0.238	0.319
Mg_1-Mg_0	0.028**	0.034	0.046*	0.037***	0.050**	0.069***	0.038**	0.052***	0.082***
S.E.± (Difference)	0.0067	0.0151	0.0155	0.0035	0.0093	0.0083	0.0075	0.0051	0.0148

continued overleaf /

TABLE 17(c) continued. EXPERIMENT I(i). GLENDEUGLIE, 1960-1965. Per cent Mg in DM of Mixed Herbage.

	1963		1964			1965	
EFFECT	Cut 1	Cut 2	Cut 1	Cut 2	Cut 3	Cut 1	Cut 2
N_0	0.138	0.256	0.173	0.221	0.295	0.153	0.213
N_1	0.163	0.268	0.206	0.245	0.329	0.146	0.234
N_1-N_0	0.025*	0.012	0.033**	0.024*	0.034	-0.007	0.021
K_0	0.170	0.284	0.213	0.253	0.353	0.155	0.244
K_1	0.131	0.240	0.166	0.214	0.271	0.144	0.203
K_1-K_0	-0.039**	-0.044*	-0.047**	-0.039**	-0.082*	-0.011	-0.041
S.E.± (Difference)	0.0062	0.0095	0.0047	0.0066	0.0170	0.0267	0.0156
NK Interaction							
N_0K_0	0.154	0.273	0.193	0.233	0.335	0.158	0.235
N_1K_0	0.187	0.295	0.233	0.273	0.370	0.153	0.253
N_0K_1	0.122	0.238	0.153	0.210	0.255	0.148	0.190
N_1K_1	0.140	0.242	0.180	0.218	0.288	0.140	0.215
S.E.± (Difference)	0.0088	0.0134	0.0066	0.0093	0.0240	0.0378	0.0221
Mg_0	0.128	0.232	0.165	0.203	0.284	0.135	0.188
Mg_1	0.173	0.292	0.214	0.264	0.340	0.164	0.259
Mg_1-Mg_0	0.045***	0.060**	0.049***	0.061***	0.056***	0.029	0.071**
S.E.± (Difference)	0.0061	0.0135	0.007	0.007	0.0101.	0.0127	0.0142

TABLE 18(a). EXPERIMENT I(i). KINGSIDE, 1960 - 1964. Uptake of Mg (lb per acre) by Mixed Herbage.

	1960				1961				1962			
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	1.6	7.3	4.8	13.7	1.5	12.3	4.2	18.0	2.3	6.8	1.6	10.7
N_1	5.9	3.3	2.4	11.6	3.4	5.7	3.3	12.4	4.2	3.8	1.1	9.1
N_1-N_0	4.3***	-4.0***	-2.4**	-2.1*	1.9***	-6.6**	-0.9	-5.6**	1.9**	-3.0**	-0.5	-1.6
K_0	3.8	6.1	3.7	13.6	2.3	9.9	3.8	16.0	2.8	5.5	1.2	9.5
K_1	3.7	4.5	3.5	11.7	2.5	8.1	3.7	14.3	3.6	5.0	1.5	10.1
K_1-K_0	-0.1	-1.6**	-0.2	-1.9*	0.2	-1.8	-0.1	-1.7	0.8*	-0.5	0.3	0.6
S.E.± (Difference)	0.17	0.24	0.42	0.41	0.08	0.57	0.39	0.83	0.21	0.34	0.23	0.67
NK Interaction												
N_0K_0	1.6	8.5	4.9	15.0	1.2*	13.6	4.3	19.1	1.8	7.0	1.4	10.2
N_1K_0	6.0	3.7	2.5	12.2	3.4	6.2	3.2	12.9	3.9	4.1	0.9	8.9
N_0K_1	1.6	6.1	4.8	12.5	1.7	11.1	4.1	16.9	2.8	6.5	1.8	11.1
N_1K_1	5.7	2.9	2.3	10.9	3.3	5.1	3.3	11.8	4.5	3.4	1.2	9.1
S.E.± (Difference)	0.24	0.34	0.60	0.59	0.12	0.80	0.55	1.17	0.29	0.48	0.33	0.95
Mg_0	3.4	4.8	3.2	11.4	2.1	8.3	3.4	13.8	3.0	4.8	1.3	9.1
Mg_1	4.0	5.8	4.0	13.8	2.7	9.7	4.1	16.5	3.5	5.7	1.4	10.6
Mg_1-Mg_0	0.6	1.0*	0.8	2.4**	0.6	1.4*	0.7***	2.7**	0.5***	0.9*	0.1	1.5**
S.E.± (Difference)	0.25	0.34	0.40	0.59	0.33	0.51	0.07	0.64	0.10	0.26	0.12	0.32

continued overleaf /

TABLE 18(a) continued EXPERIMENT I(i). KINGSIDE, 1960-1964. Uptake of Mg (lb per acre) by Mixed Herbage.

EFFECT	1963 Cut 1	Cut 2	Cut 3	Total	1964 Cut 1	Cut 2	Total
N_0	2.0	4.8	2.2	9.0	6.3	2.5	8.8
N_1	3.4	5.4	4.1	12.9	9.0	2.8	11.8
N_1-N_0	1.4*	0.6	1.9***	3.9*	2.7**	0.3	3.0**
K_0	2.8	5.2	3.1	11.1	7.3	2.6	9.9
K_1	2.6	5.0	3.1	10.7	7.9	2.7	10.6
K_1-K_0	-0.2	-0.2	0	-0.4	0.6	0.1	0.7
S.E.± (Difference)	0.37	0.66	0.10	0.88	0.33	0.26	0.38
NK Interaction							
N_0K_0	2.1	4.7	2.0	8.8	5.7	2.5	8.2
N_1K_0	3.4	5.7	4.2	13.3	8.9	2.6	11.5
N_0K_1	1.9	4.9	2.3	9.1	6.8	2.5	9.3
N_1K_1	3.4	5.1	4.0	12.5	9.0	3.0	12.0
S.E.± (Difference)	0.53	0.93	0.15	1.25	0.47	0.37	0.54
Mg_0	2.5	4.7	3.0	10.2	7.2	2.5	9.7
Mg_1	2.9	5.5	3.3	11.7	8.0	2.8	10.8
Mg_1-Mg_0	0.4	0.8***	0.3	1.5***	0.8**	0.3	1.1*
S.E.± (Difference)	0.23	0.13	0.12	0.28	0.19	0.25	0.34

TABLE 18(b) EXPERIMENT I(1). SHARPLAW, 1960 - 1964. Uptake of Mg (lb per acre) by Mixed Herbage.

EFFECT	1960				1961				1962			
	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	1.8	5.8	6.6	14.2	4.2	8.1	6.7	19.0	4.1	4.9	3.1	12.1
N_1	5.4	2.8	4.0	12.2	5.0	4.9	4.3	14.2	5.7	2.7	2.2	10.6
N_1-N_0	3.6**	-3.0*	-2.6	-2.0	0.8	-3.2**	-2.4	-4.8	1.6**	-2.2*	-0.9	-1.5
K_0	3.5	3.9	5.1	12.5	4.3	5.8	5.0	15.1	4.7	3.0	2.3	10.0
K_1	3.7	4.7	5.5	13.9	4.8	7.2	6.0	18.0	5.1	4.6	3.0	12.7
K_1-K_0	0.2	0.8	0.4	1.4	0.5	1.4	1.0	2.9	0.4	1.6*	0.7	2.7
S.E.± (Difference)	0.29	0.73	1.20	1.87	0.27	0.44	1.10	1.54	0.23	0.41	0.50	1.05
NK Interaction												
N_0K_0	1.6	4.9	6.1	12.6	3.6	6.7	5.8	16.1	3.3*	3.7	2.5	9.5
N_1K_0	5.4	2.9	4.0	12.2	5.1	4.9	4.3	14.3	6.0	2.4	2.0	10.4
N_0K_1	2.0	6.7	7.0	15.7	4.7	9.5	7.6	21.8	4.8	6.2	3.6	14.6
N_1K_1	5.4	2.6	4.0	12.0	4.9	4.9	4.3	14.1	5.4	3.0	2.5	10.9
S.E.± (Difference)	0.40	1.04	1.69	2.64	0.38	0.62	1.56	2.18	0.32	0.58	0.70	1.48
Mg_0	3.0	3.7	4.6	11.3	3.7	5.1	4.6	13.4	4.0	3.0	2.2	9.2
Mg_1	4.2	4.8	6.0	15.0	5.5	7.9	6.3	19.7	5.7	4.6	3.0	13.3
Mg_1-Mg_0	1.2***	1.1**	1.4**	3.7***	1.8***	2.8**	1.7	6.3***	1.7***	1.6***	0.8**	4.1***
S.E.± (Difference)	0.14	0.25	0.35	0.34	0.26	0.73	0.76	0.96	0.25	0.27	0.21	0.47

continued overleaf /

TABLE 18(b) continued. EXPERIMENT I(i). SHARPLAW, 1960-1964. Uptake of Mg(lb per acre) of Mixed Herbage.

	1963				1964		
EFFECT	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Total
N_0	3.3	3.3	2.1	8.7	5.6	0.8	6.4
N_1	5.0	4.4	4.0	13.4	8.5	1.2	9.7
N_1-N_0	1.7*	1.1*	1.9**	4.7**	2.9**	0.4*	3.3**
K_0	4.2	3.5	3.2	10.9	7.1	1.1	8.2
K_1	4.1	4.1	2.9	11.1	7.0	0.9	7.9
K_1-K_0	-0.1	0.6	-0.3	0.2	-0.1	-0.2	-0.3
S.E.± (Difference)	0.31	0.31	0.27	0.70	0.29	0.10	0.35
NK Interaction							
N_0K_0	3.3	2.9	2.2	8.4	5.7	0.9	6.6
N_1K_0	5.1	4.1	4.3	13.5	8.6	1.3	9.9
N_0K_1	3.4	3.6	2.1	9.1	5.4	0.8	6.2
N_1K_1	4.9	4.6	3.8	13.3	8.5	1.1	9.6
S.E.± (Difference)	0.44	0.44	0.38	0.99	0.41	0.14	0.49
Mg_0	3.5	3.4	2.7	9.6	6.7	0.9	7.6
Mg_1	4.8	4.2	3.4	12.4	7.4	1.1	8.5
Mg_1-Mg_0	1.3*	0.8**	0.7**	2.8***	0.7	0.2	0.9
S.E.± (Difference)	0.45	0.17	0.15	0.48	0.38	0.08	0.40

TABLE 18(c) EXPERIMENT I(i). GLENDEUGLIE, 1960 - 1964. Uptake of Mg (lb per acre) by Mixed Herbage.

EFFECT	1960				1961				1962			
	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total	Cut 1	Cut 2	Cut 3	Total
N_0	2.3	2.2	2.9	7.4	1.9	4.5	4.1	10.5	2.5	2.0	2.4	6.9
N_1	6.4	1.9	2.5	10.8	4.1	4.1	3.2	11.4	4.3	2.4	2.1	8.8
N_1-N_0	4.1	-0.3	-0.4	3.4**	2.2***	-0.4	-0.9*	0.9	1.8***	0.4*	-0.3	1.9*
K_0	4.8	2.0	2.4	9.2	2.9	4.2	3.1	10.2	3.1	2.3	2.2	7.6
K_1	4.0	2.1	3.0	9.1	3.0	4.4	4.2	11.6	3.8	2.2	2.3	8.3
K_1-K_0	-0.8	0.1	0.6*	-0.1	0.1	0.2	1.1*	1.4	0.7*	-0.1	0.1	0.7
S.E.± (Difference)	0.48	0.12	0.15	0.54	0.14	.43	0.26	0.55	0.14	0.11	0.20	0.34
NK Interaction												
N_0K_0	2.2	2.1	2.4	6.7	1.7	4.2	3.5	9.4	2.4	2.0	2.4	6.8
N_1K_0	7.4	1.8	2.4	11.6	4.1	4.3	2.6	11.0	3.9	2.5	2.0	8.4
N_0K_1	2.5	2.3	3.4	8.2	2.0	4.8	4.7	11.5	2.7	2.0	2.5	7.2
N_1K_1	5.4	2.0	2.5	9.9	4.1	4.0	3.8	11.9	4.8	2.3	2.2	9.3
S.E.± (Difference)	0.67	0.17	0.22	0.76	0.20	0.61	0.36	0.78	0.19	0.15	0.28	0.48
Mg_0	3.8	1.9	2.4	8.1	2.5	3.6	3.4	9.5	2.9	2.0	1.8	6.7
Mg_1	4.9	2.2	2.9	10.0	3.5	5.0	3.9	12.4	3.9	2.5	2.7	9.1
Mg_1-Mg_0	1.1	0.3	0.5	1.9	1.0***	1.4**	0.5	2.9***	1.0***	0.5***	0.9**	2.4***
S.E.± (Difference)	0.63	0.19	0.22	0.81	0.11	0.35	0.23	0.43	0.17	0.07	0.19	0.38

continued overleaf /

TABLE 18(c) continued. EXPERIMENT I(i). GLENDEUGLIE, 1960-1964. Uptake of Mg (lb per acre) by Mixed Herbage.

EFFECT	1963			1964			
	Cut 1	Cut 2	Total	Cut 1	Cut 2	Cut 3	Total
N_0	2.9	4.1	7.0	1.8	6.1	1.1	9.0
N_1	4.6	3.9	8.5	4.1	6.4	1.3	11.8
N_1-N_0	1.7**	-0.2	1.5*	2.3**	0.3	0.2	2.8*
K_0	3.6	3.7	7.3	3.0	6.3	1.1	10.4
K_1	3.9	4.2	8.1	2.9	6.2	1.3	10.4
K_1-K_0	0.3	0.5	0.8	-0.1	-0.1	0.2	0
S.E.± (Difference)	0.14	0.41	0.41	0.27	0.37	0.12	0.65
N_0K_0	2.7	3.8	6.5	1.7	5.8	0.9	8.4
N_1K_0	4.5	3.7	8.2	4.3	6.9	1.2	12.4
N_0K_1	3.1	4.4	7.5	1.8	6.5	1.3	9.6
N_1K_1	4.8	4.1	8.9	4.0	5.9	1.3	11.2
S.E.± (Difference)	0.20	0.58	0.58	0.38	0.52	0.16	0.91
Mg_0	3.3	3.6	6.9	2.6	5.5	1.0	9.1
Mg_1	4.3	4.3	8.6	3.3	7.0	1.3	11.6
Mg_1-Mg_0	1.0***	0.7**	1.7***	0.7*	1.5***	0.3	2.5***
S.E.± (Difference)	0.13	0.19	0.28	0.25	0.05	0.16	0.35

TABLE 19(a). Experiment I (i). NKMg on grass.

Soil data: exchangeable Ca, K and Mg concentrations (mg per 100 g soil) and pH values at Kingside on 21 December, 1964.

	Ca	K	Mg	pH
N_0	225	5.3	14.1	5.9
N_1	205	5.1	12.9	5.6
N_1-N_0	- 20	-0.2	-1.2	-0.3
K_0	215	5.0	13.6	5.8
K_1	215	5.4	13.3	5.7
K_1-K_0	0	0.4*	-0.3	-0.1
S.E.± (Difference)	37.8	0.14	0.52	
N_0K_0	227	5.0	14.1	5.9
N_1K_0	203	5.0	13.2	5.7
N_0K_1	223	5.6	14.1	5.8
N_1K_1	207	5.2	12.5	5.6
S.E.± (Difference)	53.5	0.18	0.74	
Mg_0	215	5.3	8.8	5.7
Mg_1	215	5.1	18.1	5.8
Mg_1-Mg_0	0	-0.2	9.3***	0.1
S.E.± (Difference)	5.1	0.22	0.33	

TABLE 19(b). Experiment I (i). NKMg on grass.

Soil data: exchangeable Ca, K and Mg concentrations (mg per 100 g soil) and pH values at Sharplaw on 22 December, 1964.

	Ca	K	Mg	pH
N_0	173	3.6	9.5	6.1
N_1	171	3.3	8.9	5.8
N_1-N_0	- 2	-0.3	-0.6	-0.3
K_0	167	3.4	9.7	5.9
K_1	177	3.4	8.7	5.9
K_1-K_0	10	0	-1.0*	0
S.E.± (Difference)	14.9	0.51	0.30	
N_0K_0	172	3.5	10.0	6.1
N_1K_0	162	3.4	9.5	5.8
N_0K_1	174	3.6	9.0	6.1
N_1K_1	180	3.2	8.4	5.8
S.E.± (Difference)	21.1	0.72	0.42	
Mg_0	166	3.4	4.5	5.9
Mg_1	178	3.4	13.9	6.0
Mg_1-Mg_0	12	0	9.4***	0.1
S.E.± (Difference)	17.6	0.10	0.28	

TABLE 19(c). Experiment I (i). NKMg on grass.

Soil data: exchangeable Ca, K and Mg concentrations (mg per 100 g soil) and pH values at Glendeuglie on 5 January 1965.

	Ca	K	Mg	pH
N_0	271	7.1	16.4	6.6
N_1	240	5.5	15.9	6.5
N_1-N_0	-31	-1.6	- 0.5	-0.1
K_0	272	5.4	16.2	6.7
K_1	239	7.1	16.1	6.5
K_1-K_0	-33	1.7	- 0.1	-0.2
S.E.± (Difference)	23.0	0.62	1.07	
N_0K_0	289	5.8	16.5	6.8
N_1K_0	255	5.0	15.9	6.6
N_0K_1	254	8.4	16.3	6.5
N_1K_1	225	5.9	15.9	6.4
S.E.± (Difference)	32.5	0.88	1.51	
Mg_0	273	6.1	8.2	6.6
Mg_1	238	6.5	24.2	6.5
Mg_1-Mg_0	-35**	0.4	16.0***	-0.1
S.E.± (Difference)	6.5	0.67	0.61	

TABLE 20(a). Experiment I (i). NKMg on grass.

Botanical composition of swards at Kingside in July, 1965.

	Per cent ground cover					
	N_0K_0	N_1K_0	N_0K_1	N_1K_1	Mg_0	Mg_1
Perennial ryegrass	3.3	4.0	4.5	4.5	4.4	3.8
Cocksfoot	10.7	18.7	17.5	22.5	18.4	16.4
Timothy	0.7	0.7	0.5	0.3	0.7	0.4
R.S. Meadow grass	2.3	1.0	2.3	0.7	1.9	1.2
Yorkshire fog	14.7	18.5	5.0	13.5	12.4	13.5
Agrostis	5.7	13.5	9.5	15.5	11.0	11.1
Other grasses	2.5	2.7	1.5	1.5	2.5	1.6
White clover	21.3	-	18.3	0.3	10.0	9.9
Red clover	0.5	-	2.0	-	0.3	1.0
Broad-leaved weeds	20.0	11.3	15.7	8.0	13.0	14.5
Bare ground and moss	19.3	29.5	23.3	33.3	25.5	26.6

TABLE 20(b). Experiment I(i). NKMg on grass.

Botanical composition of swards at Sharplaw in July 1965.

	Per cent ground cover					
	N_0K_0	N_1K_0	N_0K_1	N_1K_1	Mg_0	Mg_1
Perennial ryegrass	12.3	15.3	9.7	9.0	12.9	10.3
Cocksfoot	17.3	26.5	23.3	33.3	26.1	23.9
Timothy	1.5	2.5	1.3	1.5	2.1	1.3
R.S. Meadow grass	7.7	5.7	8.0	2.7	6.1	6.0
Other grasses	13.3	5.3	6.5	8.0	7.4	9.1
White clover	7.7	-	10.3	0.3	6.1	3.0
Broad-leaved weeds	6.7	1.7	5.3	-	3.5	3.4
Bare ground and moss	33.3	43.0	35.7	45.3	35.7	43.1

TABLE 20(c). Experiment I(i). NKMg on grass.

Botanical composition of swards at Glendauglie in May 1965.

	Per cent ground cover					
	N_0K_0	N_1K_0	N_0K_1	N_1K_1	Mg_0	Mg_1
Perennial ryegrass	5.3	3.5	3.5	5.3	3.6	5.1
Cocksfoot	11.7	23.0	14.7	17.5	16.9	16.6
Timothy	0.7	0.7	0.7	0.3	0.7	0.5
R.S. Meadow grass	11.5	12.3	11.3	12.5	12.4	11.4
Red fescue	9.0	10.0	9.5	5.5	10.0	7.0
Yorkshire fog	1.3	1.0	2.3	1.7	2.0	1.1
Agrostis	14.0	9.0	4.5	10.3	10.0	8.9
White clover	17.3	3.5	36.0	20.3	17.0	21.5
Broad-leaved weeds	21.7	18.0	11.7	12.0	16.1	15.6
Other species	0.5	-	0.3	0.3	0.3	0.3
Bare ground and moss	7.0	19.0	5.5	14.5	11.0	12.0

TABLE 21 (a). Experiment I (ii) Mg compounds on grass.

Yield of dry matter (cwt per acre).

		Treatments.									
Year	Cut	A	B	C	D	E	F	G	H	SIG.	S.E. ±
1964	1	38.5	43.7	43.3	38.8	43.2	42.1	43.1	38.2	N.S.	1.65
	2	15.7	15.7	16.4	16.1	15.7	14.4	19.2	16.7	**	0.54
	3	5.1	5.3	6.0	5.4	4.4	5.2	4.3	4.8	N.S.	0.42
	Total	59.3	64.7	65.6	60.3	63.4	61.8	66.5	59.7	N.S.	1.83
1965	1	35.6	35.3	33.5	33.9	34.9	33.4	35.0	35.4	N.S.	1.08
	2	22.1	22.8	23.3	22.5	23.3	22.9	20.2	23.0	N.S.	0.95
	3	5.7	5.7	6.6	6.4	5.7	5.8	6.1	6.6	N.S.	0.31
	4	2.3	2.3	3.2	2.9	2.2	2.6	2.6	3.1	*	0.22
	Total	65.7	66.1	66.6	65.6	66.1	64.7	63.9	68.0	N.S.	1.56
1966	1	32.5	33.1	33.9	32.3	33.3	32.1	32.2	32.8	N.S.	1.55
	2	18.8	20.5	20.3	19.5	20.6	20.7	20.2	21.5	N.S.	0.66
	3	4.1	4.7	5.3	4.8	4.7	4.5	4.5	4.0	**	0.21
	4	2.8	2.8	3.4	3.1	2.7	3.4	3.2	2.8	N.S.	0.27
	Total	58.2	61.0	62.8	59.7	61.3	60.7	60.1	61.1	N.S.	1.89
1967	1	31.4	32.2	31.2	33.0	32.5	31.9	30.0	31.5	N.S.	1.30
	2	13.6	13.9	14.6	13.3	14.6	16.5	14.2	14.1	N.S.	0.73
	3	3.9	4.9	6.3	5.0	5.3	5.9	4.8	4.6	N.S.	0.67
	Total	48.9	51.0	52.1	51.3	52.5	54.3	48.9	50.2	N.S.	2.03

TABLE 22 (a). Experiment I (ii). Mg compounds on grass.

Per cent N in the dry matter of herbage.

Year	Cut	Treatments A	B	C	D	E	F	G	H	SIG.	S.E.±
1964	1	1.91	1.80	1.76	1.81	1.87	1.77	2.00	1.75	*	0.056
	2	1.22	1.26	1.21	1.23	1.30	1.11	1.15	1.24	N.S.	0.077
	3	2.41	2.39	2.41	2.46	2.40	2.44	2.12	2.45	N.S.	0.105
1965	1	2.13	2.18	2.30	2.10	2.30	2.27	2.09	2.20	N.S.	0.103
	2	1.74	1.80	1.78	1.90	1.81	1.98	1.68	1.92	N.S.	0.076
	3	3.08	3.11	3.10	3.14	3.05	3.17	3.11	3.16	N.S.	0.059
	4	3.39	3.58	3.41	3.47	3.41	3.58	3.56	3.58	N.S.	0.149
1966	1	2.59	2.85	3.03	2.72	2.52	2.79	2.72	3.06	N.S.	0.140
	2	1.94	1.85	1.88	2.01	1.72	1.91	1.89	1.80	N.S.	0.100
	3	2.26	2.33	2.26	2.45	2.26	2.41	2.43	2.32	*	0.047
	4	3.40	3.41	3.33	3.38	3.44	3.40	3.47	3.41	N.S.	0.057
1967	1	2.73	2.94	2.75	2.75	2.92	3.37	2.90	3.02	*	0.125
	2	1.36	1.40	1.36	1.40	1.48	1.41	1.40	1.43	N.S.	0.057
	3	2.27	2.25	2.23	2.25	2.26	2.21	2.31	2.30	N.S.	0.057

TABLE 23 (a). Experiment I (ii). Mg compounds on grass.

Per cent P in the dry matter of herbage.

Year	Cut	Treatments A	B	C	D	E	F	G	H	SIG.	S.E.±
1964	1	0.30	0.28	0.27	0.29	0.30	0.29	0.33	0.28	***	0.006
	2	0.23	0.23	0.24	0.24	0.24	0.24	0.22	0.23	N.S.	0.005
	3	0.36	0.34	0.35	0.35	0.35	0.34	0.38	0.33	*	0.008
1965	1	0.32	0.33	0.34	0.33	0.36	0.34	0.34	0.32	N.S.	0.008
	2	0.31	0.29	0.28	0.32	0.30	0.28	0.31	0.30	*	0.009
	3	0.44	0.44	0.44	0.44	0.44	0.43	0.46	0.44	N.S.	0.007
	4	0.48	0.49	0.47	0.48	0.49	0.48	0.51	0.46	N.S.	0.009
1966	1	0.35	0.37	0.40	0.36	0.37	0.35	0.38	0.37	N.S.	0.012
	2	0.34	0.36	0.35	0.35	0.35	0.35	0.35	0.31	*	0.009
	3	0.44	0.45	0.42	0.45	0.44	0.43	0.44	0.43	N.S.	0.010
	4	0.55	0.54	0.54	0.55	0.55	0.54	0.56	0.53	N.S.	0.007
1967	1	0.43	0.45	0.46	0.43	0.46	0.49	0.45	0.46	N.S.	0.015
	2	0.27	0.28	0.28	0.28	0.28	0.29	0.29	0.27	N.S.	0.008
	3	0.45	0.45	0.45	0.44	0.48	0.45	0.48	0.46	N.S.	0.015

TABLE 24 (a). Experiment I (ii). Mg compounds on grass.

Per cent K in the dry matter of herbage.

Year	Cut	Treatments A	B	C	D	E	F	G	H	SIG.	S.E.±
1964	1	2.76	2.74	2.59	2.75	2.80	2.82	2.84	2.70	N.S.	0.076
	2	1.41	1.54	1.57	1.50	1.65	1.56	1.48	1.51	N.S.	0.059
	3	2.32	2.25	2.23	2.19	2.26	2.30	2.27	2.28	N.S.	0.062
1965	1	3.22	3.32	3.45	3.32	3.44	3.50	3.32	3.24	N.S.	0.129
	2	2.49	2.27	2.39	2.50	2.41	2.45	2.41	2.51	N.S.	0.095
	3	3.21	3.21	3.27	3.17	3.26	3.31	3.26	3.18	N.S.	0.050
	4	2.86	2.80	2.88	2.84	2.82	2.93	2.90	2.89	N.S.	0.074
1966	1	3.55	3.49	3.29	3.40	3.52	3.45	3.37	3.44	N.S.	0.121
	2	3.14	3.16	3.16	2.87	3.21	3.41	3.11	3.05	N.S.	0.160
	3	2.94	2.92	3.05	2.98	3.10	3.05	2.87	2.83	N.S.	0.095
	4	3.27	3.19	3.37	3.04	3.40	3.37	3.33	3.32	N.S.	0.093
1967	1	3.55	3.64	3.51	3.29	3.63	3.84	3.53	3.57	N.S.	0.131
	2	1.99	2.24	2.10	2.09	2.20	2.38	2.20	2.04	N.S.	0.105
	3	2.51	2.46	2.50	2.23	2.44	2.53	2.44	2.51	N.S.	0.105

TABLE 25 (a). Experiment I (ii). Mg compounds on grass.

Per cent Ca in the dry matter of herbage.

Year	Cut	Treatments A	B	C	D	E	F	G	H	SIG.	S.E.±
1964	1	0.46	0.43	0.37	0.36	0.42	0.38	0.42	0.44	**	0.015
	2	0.53	0.57	0.42	0.50	0.46	0.43	0.44	0.58	*	0.039
	3	0.95	0.93	0.87	0.86	0.91	0.89	0.71	0.96	N.S.	0.057
1965	1	0.49	0.52	0.49	0.46	0.52	0.54	0.51	0.51	N.S.	0.029
	2	0.76	0.77	0.67	0.71	0.73	0.82	0.67	0.71	N.S.	0.051
	3	0.89	0.85	0.80	0.77	0.85	0.84	0.81	0.86	N.S.	0.047
	4	0.64	0.64	0.60	0.62	0.65	0.65	0.64	0.68	N.S.	0.027
1966	1	0.32	0.37	0.39	0.35	0.33	0.34	0.41	0.38	N.S.	0.021
	2	0.60	0.55	0.57	0.57	0.49	0.51	0.57	0.46	N.S.	0.040
	3	0.66	0.69	0.63	0.67	0.61	0.65	0.70	0.69	N.S.	0.027
	4	0.73	0.71	0.66	0.67	0.70	0.68	0.70	0.72	N.S.	0.023
1967	1	0.41	0.36	0.39	0.34	0.35	0.29	0.35	0.39	N.S.	0.023
	2	0.55	0.57	0.50	0.47	0.58	0.48	0.59	0.65	N.S.	0.050
	3	0.79	0.73	0.73	0.69	0.70	0.69	0.82	0.79	*	0.028

TABLE 26 (a). Experiment I (ii). Mg compounds on grass.

Per cent Mg in the dry matter of herbage.

Year	Cut	Treatments A	B	C	D	E	F	G	H	SIG.	S.E.±
1964	1	0.103	0.123	0.130	0.148	0.120	0.113	0.120	0.115	**	0.0067
	2	0.133	0.133	0.138	0.153	0.130	0.133	0.113	0.130	N.S.	0.0087
	3	0.198	0.218	0.283	0.295	0.208	0.225	0.205	0.248	***	0.0126
1965	1	0.120	0.140	0.148	0.155	0.148	0.128	0.138	0.153	*	0.0070
	2	0.150	0.160	0.175	0.205	0.175	0.178	0.185	0.180	N.S.	0.0149
	3	0.225	0.248	0.270	0.303	0.255	0.255	0.263	0.265	***	0.0084
	4	0.185	0.208	0.235	0.260	0.205	0.215	0.223	0.248	**	0.0108
1966	1	0.133	0.150	0.160	0.165	0.158	0.175	0.153	0.160	**	0.0063
	2	0.155	0.170	0.198	0.220	0.183	0.218	0.175	0.180	**	0.0101
	3	0.223	0.243	0.243	0.295	0.255	0.283	0.253	0.278	***	0.0086
	4	0.250	0.260	0.283	0.335	0.295	0.308	0.278	0.298	***	0.0091
1967	1	0.145	0.158	0.175	0.190	0.213	0.228	0.180	0.185	***	0.0084
	2	0.183	0.193	0.198	0.218	0.230	0.243	0.198	0.243	**	0.0115
	3	0.253	0.265	0.288	0.323	0.328	0.338	0.280	0.293	***	0.0100

TABLE 26 (b). Experiment I (ii). Mg compounds on grass.

Uptake of Mg (lb per acre) by herbage.

		Treatments									
Year	Cut	A	B	C	D	E	F	G	H	SIG.	S.E.±
1964	1	4.4	6.0	6.3	6.5	5.8	5.4	5.8	4.9	*	0.41
	2	2.3	2.3	2.5	2.7	2.3	2.1	2.4	2.4	N.S.	0.16
	3	1.1	1.3	1.9	1.8	1.0	1.3	1.0	1.3	**	0.15
	Total	7.9	9.6	10.7	11.0	9.1	8.8	9.2	8.6	**	0.53
1965	1	4.9	5.0	5.3	4.6	5.2	4.8	5.6	5.2	N.S.	0.32
	2	3.7	4.1	4.6	5.2	4.6	4.6	4.2	4.6	N.S.	0.43
	3	1.4	1.6	2.0	2.2	1.6	1.7	1.8	1.9	**	0.12
	4	0.5	0.5	0.9	0.8	0.5	0.6	0.7	0.9	***	0.06
	Total	10.5	11.2	12.7	12.7	11.9	11.7	12.2	12.6	N.S.	0.56
1966	1	4.8	5.6	6.1	6.0	5.9	6.3	5.5	5.6	N.S.	0.30
	2	3.3	3.9	4.5	4.8	4.2	5.0	4.0	4.4	**	0.29
	3	1.0	1.3	1.4	1.6	1.3	1.4	1.3	1.2	***	0.06
	4	0.7	0.8	1.1	1.2	0.9	1.2	1.0	1.0	*	0.09
	Total	9.8	11.6	13.1	13.5	12.3	13.9	11.7	12.2	***	0.48
1967	1	5.1	5.7	6.1	7.0	7.7	8.1	6.1	6.5	***	0.39
	2	2.8	3.0	3.2	3.2	3.7	4.4	3.1	3.8	**	0.25
	3	1.1	1.4	1.9	1.8	1.9	2.1	1.5	1.4	*	0.20
	Total	9.0	10.1	11.3	12.0	13.4	14.7	10.6	11.8	***	0.54
4 Years Total		37.1	42.5	47.7	49.2	46.8	49.1	43.7	45.1		

TABLE 27 (a). Experiment I (ii). Mg compounds on grass.

Soil data: exchangeable Ca, K and Mg concentrations (mg per 100 g soil) and pH values, at 4 sampling dates.

	Date	A	B	C	D	E	F	G	H	SIG.	S.E.±
Ca	5. 1.65	195	199	193	202	201	195	190	195	N.S.	5.8
	30. 3.65	210	209	206	201	206	208	206	208	N.S.	4.1
	4. 4.66	163	165	161	155	160	160	163	164	N.S.	5.4
	22.12.66	175	181	174	172	179	166	173	181	N.S.	5.3
K	5. 1.65	11.9	9.7	10.7	10.7	12.1	11.6	11.9	11.4	N.S.	0.92
	30. 3.65	9.6	9.7	8.9	9.1	11.3	10.0	8.7	9.6	N.S.	0.77
	4. 4.66	11.2	11.2	11.3	11.1	11.6	11.4	10.6	10.6	N.S.	0.77
	22.12.66	7.6	7.9	7.6	7.7	7.8	7.7	8.1	8.1	N.S.	0.25
Mg	5. 1.65	8.9	9.9	12.2	16.7	9.6	10.7	9.9	12.2	***	0.47
	30. 3.65	7.4	8.1	10.1	14.1	7.6	8.4	7.4	10.8	***	0.39
	4. 4.66	8.4	10.6	12.0	17.3	9.9	10.9	9.8	15.8	***	0.49
	22.12.66	7.6	10.2	13.1	18.0	12.1	16.0	11.1	16.5	***	0.50
pH	5. 1.65	6.3	6.3	6.2	6.4	6.3	6.2	6.2	6.3		
	30. 3.65	6.3	6.2	6.2	6.3	6.2	6.2	6.2	6.3		
	4. 4.66	5.8	5.8	5.8	6.1	5.9	5.9	5.9	6.0		
	22.12.66	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.5		

TABLE 28(a). Experiment II. NKMg on Barley.

Per cent N, P, K and Mg in the DM of leaf samples taken in July.

Treatments	Per cent in Dry Matter.			
NKMg	N	P	K	Mg
0 0 0	3.01	0.299	3.34	0.100
0 0 1	2.99	0.297	3.31	0.119
0 1 0	3.30	0.313	3.66	0.087
0 1 1	3.04	0.293	3.46	0.102
1 0 0	3.47	0.308	3.55	0.102
1 0 1	3.12	0.273	3.12	0.123
1 1 0	3.35	0.278	3.66	0.098
1 1 1	3.16	0.278	3.34	0.107
S.E.±	0.105	0.0144	0.128	0.0040
N_0	3.08	0.300	3.44	0.102
N_1	3.28	0.284	3.42	0.108
N_1-N_0	0.20*	-0.016	-0.02	0.006
K_0	3.15	0.294	3.33	0.111
K_1	3.21	0.291	3.53	0.099
K_1-K_0	0.06	-0.003	0.20*	-0.012***
Mg_0	3.28	0.299	3.55	0.097
Mg_1	3.08	0.285	3.31	0.113
Mg_1-Mg_0	-0.20*	-0.014	-0.24*	0.016***
S.E.±	0.052	0.0072	0.064	0.0020

TABLE 29(a). Experiment II. NKMg on Barley

Per cent N. P, K and Mg in the DM of grain at harvest.

Treatments	Per cent in Dry Matter.			
NKMg	N	P	K	Mg
0 0 0	1.29	0.337	0.417	0.089
0 0 1	1.21	0.329	0.440	0.092
0 1 0	1.33	0.334	0.417	0.088
0 1 1	1.25	0.339	0.450	0.091
1 0 0	1.33	0.323	0.440	0.089
1 0 1	1.25	0.329	0.457	0.091
1 1 0	1.28	0.310	0.443	0.085
1 1 1	1.27	0.322	0.453	0.089
S.E.±	0.030	0.0042	0.0176	0.0014
MAIN EFFECTS				
N_0	1.27	0.335	0.431	0.090
N_1	1.28	0.321	0.448	0.089
N_1-N_0	0.01	-0.014***	0.017	-0.001
K_0	1.27	0.330	0.438	0.090
K_1	1.28	0.326	0.441	0.088
K_1-K_0	0.01	-0.004	0.003	-0.002
Mg_0	1.31	0.326	0.429	0.088
Mg_1	1.24	0.330	0.450	0.091
Mg_1-Mg_0	-0.07*	0.004	0.021	0.003*
S.E.±	0.015	0.0021	0.0088	0.0007

* NK interaction

TABLE 30(a). Experiment II. NKMg on Barley.

Yield of grain and the uptakes of N, P, K and Mg by grain at harvest.

Treatments	Grain yield+	Uptakes (lb/acre)			
NKMg	(cwt/acre)	N	P	K	Mg
0 0 0	17.8	20.8	5.45	6.72	1.44
0 0 1	17.6	19.5	5.30	7.10	1.48
0 1 0	18.8	22.9	5.74	7.16	1.50
0 1 1	16.0	18.3	4.99	6.62	1.34
1 0 0	21.9	26.6	6.49	8.91	1.80
1 0 1	20.3	23.4	6.11	8.51	1.69
1 1 0	20.3	23.8	5.77	8.27	1.59
1 1 1	20.5	23.9	6.04	8.55	1.68
S.E.±	1.13	1.36	0.307	0.541	0.094
N_0	17.5	20.4	5.37	6.90	1.44
N_1	20.8	24.4	6.10	8.56	1.69
N_1-N_0	** 3.3	*** 4.0	** 0.73	*** 1.66	** 0.25
K_0	19.4	22.5	5.84	7.81	1.60
K_1	18.9	22.2	5.63	7.65	1.53
K_1-K_0	- 0.5	- 0.3	-0.21	-0.16	-0.07
Mg_0	19.7	23.5	5.86	7.76	1.58
Mg_1	18.6	21.3	5.61	7.70	1.55
Mg_1-Mg_0	- 1.1	- 2.2*	-0.25	-0.06	-0.03
S.E.±	0.57	0.68	0.153	0.270	0.047

+ Yield of grain with a moisture concentration of 18 per cent.

TABLE 31(a) Experiment II. NKMg on Barley.

Per cent N, P, K and Mg in the DM of straw at harvest.

Treatments	Per cent in Dry Matter.			
NKMg	N	P	K	Mg
0 0 0	0.413	0.071	0.490	0.042
0 0 1	0.380	0.066	0.523	0.044
0 1 0	0.437	0.074	0.623	0.040
0 1 1	0.400	0.068	0.533	0.042
1 0 0	0.440	0.064	0.520	0.040
1 0 1	0.373	0.058	0.470	0.047
1 1 0	0.450	0.066	0.583	0.039
1 1 1	0.407	0.060	0.533	0.045
S.E.±	0.0143	0.0033	0.0372	0.0016
MAIN EFFECTS				
N_0	0.408	0.070	0.543	0.042
N_1	0.418	0.062	0.527	0.043
N_1-N_0	0.010	-0.008**	-0.016	0.001
K_0	0.402	0.065	0.501	0.043
K_1	0.423	0.067	0.568	0.042
K_1-K_0	0.021*	0.002	0.067*	-0.001
Mg_0	0.435	0.069	0.554	0.040
Mg_1	0.390	0.063	0.515	0.045
Mg_1-Mg_0	-0.045***	-0.006*	-0.039	0.005**
S.E.±	0.0071	0.0017	0.0186	0.0008

TABLE 32(a). Experiment III (i). NPKT on Potatoes.

Per cent DM in Tubers at harvest and N, P, K and Mg in DM.

MAIN EFFECTS.	DM(%)	N	P	K	Mg
N_1	18.2	1.55	0.157	1.75	0.059
N_2	18.0	1.68	0.156	1.81	0.061
N_2-N_1	- 0.2	0.13***	-0.001	0.06	0.002
P_1	18.0	1.63	0.155	1.80	0.061
P_2	18.2	1.60	0.158	1.76	0.059
P_2-P_1	0.2	-0.03*	0.003	-0.04	-0.002
K_1	18.3	1.62	0.158	1.66	0.057
K_2	17.8	1.62	0.155	1.89	0.063
K_2-K_1	- 0.5***	0.00	-0.003	0.23***	0.006***
S.E.±	0.07	0.011	0.0022	0.030	0.0009
Type of K	***		*		
K_2SO_4	18.2	1.62	0.155	1.76	0.060
KCl	17.6	1.62	0.152	1.84	0.060
$KHCO_3$	18.4	1.62	0.162	1.74	0.060
S.E.±	0.09	0.014	0.0027	0.037	0.0010
INTERACTIONS	PK*	NPKT*			

TABLE 33(a). Experiment III(ii). KTMg on Potatoes.

Per cent DM in leaf samples taken in August and N, K and Mg in DM.

		Per cent in Dry Matter		
MAIN EFFECTS	DM(%)	N	K	Mg
K Rate		*	***	***
K_1	17.1	4.21	1.53	0.467
K_2	16.4	3.92	1.81	0.472
K_3	16.5	4.33	2.34	0.381
K_4	16.4	4.23	2.66	0.359
S.E.±	0.23	0.103	0.104	0.0131
$K_2SO_4(T_1)$	17.2	4.35	2.27	0.406
$KCl(T_2)$	16.0	3.99	1.90	0.434
T_2-T_1	-1.2***	-0.36**	-0.37**	0.028*
Mg_0	16.7	4.24	2.07	0.375
Mg_1	16.5	4.10	2.10	0.465
Mg_1-Mg_0	-0.2	-0.14	0.03	0.090***
S.E.±	0.16	0.073	0.074	0.0093
INTERACTIONS.				*KMg ***TMg

TABLE 34(a). Experiment III(ii). KTMg on Potatoes.

Per cent DM in Tubers at harvest and N, K and Mg in DM.

		Per cent in Dry Matter		
MAIN EFFECTS	DM(%)	N	K	Mg
K Rate	***	*	***	**
K_1	25.8	1.54	1.25	0.088
K_2	25.0	1.51	1.42	0.093
K_3	24.2	1.45	1.63	0.090
K_4	24.0	1.44	1.68	0.101
S.E.±	0.19	0.026	0.040	0.0022
$K_2SO_4(T_1)$	25.3	1.45	1.44	0.095
$KCl(T_2)$	24.2	1.53	1.55	0.090
T_2-T_1	-1.1***	0.08**	0.11**	-0.005*
Mg_0	24.8	1.48	1.47	0.090
Mg_1	24.7	1.50	1.51	0.096
Mg_1-Mg_0	- 0.1	0.02	0.04	0.006*
S.E.±	0.13	0.018	0.028	0.0016

INTERACTIONS. There were no significant interactions.

TABLE 35(a) Experiment III (ii). KTMg on Potatoes.

Yield of Tubers and the upstakes of N, K and Mg by tubers at harvest.

	Yield		Uptakes (lb/acre)		
MAIN EFFECTS	(1)[a]	(2)[b]	N	K	Mg
K Rate	***	**		***	***
K_1	13.0	3.34	114.9	93.3	6.6
K_2	14.5	3.63	122.7	115.5	7.6
K_3	15.6	3.77	122.6	137.4	7.6
K_4	16.2	3.89	125.5	146.2	8.8
S.E.±	0.35	0.097	3.16	5.42	0.26
$K_2SO_4(T_1)$	14.8	3.74	120.8	121.6	8.0
$KCl(T_2)$	14.8	3.57	122.1	124.6	7.3
T_2-T_1	0	-0.17	1.3	3.0	-0.7**
Mg_0	14.6	3.61	118.9	119.6	7.3
Mg_1	15.0	3.71	123.9	126.6	8.0
Mg_1-Mg_0	0.4	0.10	5.0	7.0	0.7**
S.E.±	0.25	0.069	2.24	3.83	0.18
INTERACTIONS					*KMg

a. Yield of tubers, at harvest, in tons per acre.

b. Yield of tuber dry matter, in tons per acre.